JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

VOLUME VI.

1896.

ARTILLERY SCHOOL PRESS
FORT MONROE, VIRGINIA.

VI. Complete

JULY—AUGUST.

Vol. VI. No. 1. Whole No. 21.

1896.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS,

FORT MONROE, VIRGINIA.

ENTERED AT THE POST-OFFICE AT FORTRESS MONROE, VA., AS SECOND-CLASS MATTER.

UNITED STATES ARTILLERY SCHOOL.

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School.

COMMITTEE OF DIRECTION AND PUBLICATION.

Colonel Henry W. Closson, 4th U. S. Artillery.
Captain James M. Ingalls, 1st U. S. Artillery.
Lieutenant Erasmus M. Weaver, 2nd U. S. Artillery.
Lieutenant George O. Squier, 3rd U. S. Artillery.
Lieutenant Edgar Russel, 5th U. S. Artillery.

EDITOR.

Lieutenant John P. Wisser, 1st U. S. Artillery.

ASSISTANT EDITOR.

Lieutenant George Blakely, 2nd U. S. Artillery.

Subscription . . . . [illegible]
For countries in the postal union . . . . [illegible]
Single numbers . . . . [illegible]

Subscriptions in all cases date from January 1st, and remittances should be sent to the editor at Fort Monroe, Virginia.

AGENTS.

NEW YORK.—*Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254 Fifth Avenue.
LONDON.—*B. F. Stevens*, 4 Trafalgar Square.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. VI. No. 1. JULY—AUGUST, 1896. WHOLE No. 21.

THE NAVAL ATTACK ON SEA-COAST FORTIFICATIONS.

The present ruling principles.

Strategy, in naval warfare, has to do, as on land, with large theaters and prolonged and extensive operations, and is in no way subject to change by modifications in the propulsive or fighting power of ships; but the principles of this science are the same to-day as in the days of Blake or Nelson. Naval tactics, on the contrary, are still in an undeveloped state and the practical impossibility of peace trials and experiments leave many important questions unanswered. For guides in the practice of this science there have been a few naval engagements under modern conditions, and, in addition, some experiments. As this paper has to deal with naval tactics applied to attacks on sea-coast forts, there is then to consider such events and experiments that tend to show how such attacks will be made or at least the principles generally accepted by tactical experts. The motives which impel action and the methods to be employed by naval commanders should be known and understood by commanders of sea-coast forts, and be provided for in the system of sea-coast defense.

The question to be considered by the defender of harbors is, what will a naval force try to effect? It must be granted that his enemy knows the topography of his harbors. The final object an attack ought to be perfectly understood, as it is the comment of the object of the defense. The naval commander has ertain tactical problem confronting him. What are the preibed methods of overcoming opposition presented in the tance before him? He has been taught that the fighting terial now under his control has accepted values and will acmplish or is designed to accomplish certain results. In a

measure, the probable method of attack, vulnerability, and the limits of endurance of loss or injury can be better predicated of the enemy by the land than by the water commander; for the topographical conditions compel a fixed line or lines of advance and mooring positions, the value of armor and the designs of ships are well known, and ships may be crippled in many ways, and moreover there are no reserves for depleted crews during the progress of a fight. On land, the most advantageous positions are selected for defense, the field being so to speak, especially prepared in the interests of the defenders; invulnerabiiity is a matter of thickness of earth or concrete and of disappearing carriages, and there need be no limit to the supply of men. But in addition to this general knowledge of the enemy's forces and the necessary direction of attack, the land commander ought to know the probable manner in which his naval opponent can best employ his means to break down the defense. Thus he may direct his own force with vigor and avoid becoming involved in an exhausting resistance of a mere diversion.

A few examples from history and from peace maneuvers may evolve some maxims.

NAVAL TACTICS IN RECENT HISTORY.

The attack on the sea forts at Sebastopol in October 1854, seems to establish two guiding maxims for the sea attack: 1st, Ships should not engage at the extreme range of their guns; 2d, That good passive obstructions may be depended on to prevent the run past the batteries, unless these obstructions have been especially provided against.

The attack on Kinburn shows, if it shows anything from which we may profit now-a-days, the hopelessness of opposing steel-clad ships with guns too weak to pierce their armor.

In 1858, in the French and English attack on the Chinese works at the mouth of the Peiho, we read that the defender's obstructions were broken by the prow of the leading vessel; that the heavy vessels engaged the batteries at anchor; that, covered by this fire, the lighter gunboats, filled with a landing force, ran by the batteries and took the works in rear by a land attack, the principal loss being confined to the heavy vessels. The following year an attack at the same place found conditions quite changed. The defender's obstructions held the gunboats under a close and severe fire from the fort. This also prevented the run past and the attack in rear. The storming party, attacking in front, were repulsed with heavy loss and the fleet was withdrawn. Here the

attacker failed to demolish the obstructions and therefore his attempt was fruitless.

The attack on the Charleston forts, April 7th, 1863, failed because of obstructions and confused tactics. The ships were kept on the move without concerted action and although the practice was good it seemed to have had but slight effect on the hostile fire.

The attack on the forts at Hatteras Inlet gives a strong contrast between the values of a fire from ships moving and that from ships at anchor within fair range. The accuracy with which a moving object can be found by modern range finders on shore makes the method of anchoring all the more necessary as the range finding thus becomes nearly equally facile for both sides.

The attack below New Orleans seems to show that naval fleets should be prepared to use high angle fire; and that forts need not expect to defeat ships properly protected in a run past when the obstructions fail to delay them. It shows further that the attacking fleet must remove or destroy obstructions before a run past is attempted.

The passages at Vicksburg illustrate the ease of the run past when there are no obstructions.

The various operations on the Mississippi seem to show that where the navigation is difficult it is a mistake to attempt the run past in the darkness or fog; but where the channel is broad and unobstructed, advantage should be taken of such conditions.

In 1866, in the attack by the Italians on the forts in the harbor of Lissa, little was accomplished by the fleet from various causes, not directly the result of their tactics; but rather on account of the proximity of the Austrian fleet. It may be noted, however, that although the ironclads were almost invulnerable to the enemy's artillery, still it was found necessary, in order to effect anything, to disembark troops for a land attack. The appearance of the Austrian squadron finally put a stop to further operations against the forts. From this engagement the conclusion has been drawn that a "simple bombardment does not entangle a fleet in any way or render it less fit for a sea fight, unless the expenditure of ammunition is excessive. Ships seriously engaging coast batteries, on the other hand, must sustain some damage and the crews must be more or less exhausted. A squadron under these conditions is not fit for action against an enemy of approximately equal force, whose ships are whole and whose crews are fresh".

The attack on Alexandria furnishes examples of different methods of maneuver of ships in attacks on land batteries

The *Invincible*, an armored vessel of 6000 tons and carrying 12-ton guns, together with the *Penelope*, a 4400-ton vessel carrying 9-ton guns, anchored about 1100 yards from the nearest fort, described as a "prehistoric work", and there they remained during the entire engagement, receiving little or no damage and succeeding in accomplishing nothing more than driving the Egyptain gunners under cover. Recourse was finally had to a landing party which boldly entered the Mex forts and spiked the guns. The *Monarch* an 8000-ton turreted ironclad, carrying 25-ton guns, steamed back and forth past the shore batteries of the outer harbor, produced little effect and was not struck during the fight. The *Superb*, a broadside ironclad of 9000-tons, carrying 18-ton guns, the *Alexandra* and *Sultan*, 9000-ton vessels having 25- and 18-ton guns in central batteries, entered the action at 1500 yards under way, but failing to get good practice, anchored about 1100 yards from the light house batteries. The *Temeraire*, 8500-tons, mounting 25-ton guns in barbette towers, after a useless long range fire at the Mex forts finally anchored about 1500 yards from the Pharos battery for the remainder of the fight and showed good practice. The *Inflexible*, a 12,000-ton vessel, carrying four 16-inch M. L. R., planted a buoy at a known range, steamed to it to fire, then moved away during the slow procees of loading. The practice was good.

On the part of the defense, their armament was unequal to the task of fighting ironclads, even at close range and no high angle fire was employed.

The main conclusion to be drawn from this affair might be, that when not opposed by high angle fire the ships should anchor or moor at known ranges, well within the effective power of their guns. This plan would be influenced by the vulnerability of the ships and the character of the armament.

NAVAL TACTICS IN MANEUVERS.

In the English Naval Maneuvers of 1889, a series of attacks on harbors containing large amounts of naval resources that might be utilized by the enemy was carried out, and at Dunmore, on the Irish coast, a typical river attack took place. The attacking force consisted of battleships, protected cruisers, torpedo vessels and boats. The battleships remained off the harbor to prevent interruption; the cruisers held the mouth of the river and the torpedo vessels and torpedo boats, with one well in front

to reconnoiter, advanced against the town. As the object was to destroy shipping, the plan was to run past any opposing batteries with the least loss and return. The operation is described as follows:

"A sharp lookout was kept for any hostile force that might have anticipated this movement; and as the expedition reached Duncannon, a battery at the point opened fire on it. It was only a muzzle loader of old type, and before it could be loaded a second time torpedo boat No. 60 slipped by it, only to be followed by a running fusillade of musketry from the men of an infantry battalion lining the parapets. By this time the *Sandfly* (torpedo vessel) opened fire with a 4-inch B.L.R. (her only gun) which could be discharged at least six times while the shore battery was firing a single shot. Presently too, the 3-pdr. Hotchkiss rapid firing guns raked the enemy's parapets; and every torpedo boat as it passed brought the fire of its Hotchkiss gun to bear on the fort and its garrison. By this time, too, the fort was receiving the fire of the heavy guns of the *Mohawk* and *Serpent* (cruisers) which engaged it at a range of 3500 yards, to cover the up-river movement. During the passage up the river the *Sandfly's* crew under small arms were prepared to meet the rifle fire of infantry, who might be concealed in fringes of woodland along the banks. On reaching Waterford, a few rounds were fired from the flotilla, which was followed by the surrender of the port with all its shipping and merchandise. At 3.30 P. M. the flotilla started on its return passage, during which it came a second time under the fire of Duncannon fort".

In the attack on Kingston an unprotected cruiser with torpedo boats attempted the same maneuver. The cruiser got in the cross fire of two batteries and had to withdraw. The torpedo boats stole by, destroyed shipping but were badly punished on the run out (daylight).

The French maneuvers of the same year, illustrating a naval attack on a well defended harbor are quite interesting. The intention of the fleet was the possession of the harbor of Toulon with its vast naval stores.

The situation is such that a fleet must first *overcome* hostile resistance in order to accomplish its final object. The port had an outer and an inner harbor united by two narrow passages one on each side of a long breakwater, and defended by torpedoes. Defending the outer roadstead which was about 3,000 yards at its mouth were three forts and nine heavy batteries mounting 18, 24, 27 and 32 cm. guns. The inner habor was under the

direct fire of four powerful forts. Marine infantry defended the lines between the fortifications and possible points of landing not readily commanded by the forts. Search lights were mounted in the batteries. The squadron was sighted about evening but the attack was not made until dark. The advance was made in column of divisions, battleships in the van, with torpedo boats and vessels in front as scouts and on the flanks to obtain information and to destroy search lights. As the attack opened, the squadron formed line abreast, a light vessel remaining in rear to repeat signals, and each division opened fire on the forts and batteries on its own side. The fleet made several attempts to put out the shore lights, but by concentrating fire on vessels so attempting, this was frustrated. The fleet steamed slowly during the fire, so as not to cross the line of torpedoes, and to prolong the fire of the attack. The day attack made on the following afternoon was a repetition of this in the formation and plan for the fire of the ships. It was shown that the ships were under heavy fire from the outer forts alone, for twenty-five minutes, partly on account of the attack formation and partly because of the intricacies of the harbor.

The various other operations in these maneuvers showed that the most effective adjunct to harbor defense is the search light, and, if in sufficient numbers, they can make the night attack, even of torpedo boats, in a well defended harbor a very perilous undertaking, whatever the enemy's tactical arrangements.

The German maneuvers of 1891 illustrated in a most interesting manner a method of attack on strong harbor defenses. Kiel, the point selected, is the most important German port on the Baltic, situated at the head of an arm of the sea, about a mile and a quarter wide at the narrowest part and about ten miles long, the entrance to which was guarded by nine modern, heavily armed works. The mobile defense consisted of four battleships, one torpedo vessel and eight torpedo boats. The attacking squadron consisted of four battleships, an armored gun vessel, one torpedo vessel and twenty smaller torpedo vessels and boats, two of these being used as dispatch boats. The attack is described as follows:

"On the morning of the third of September, when hostilities were declared, the attacking force was at sea. The port was closed at once; that is, buoys, lights, and leading marks were supposed to be removed, and vessels were not permitted to enter without pilots. The forts were manned as for actual war. The small port of Laboe, west of Röpsdorf and close to the mouth

of the fiord, was occupied by three hundred men of the marine battalion. The neighboring coast was lined with troops. A mine field and other obstructions were laid out between Friedrichsort and Maltenort. A number of extra batteries were planted on both coasts, and a lookout station was established at the end of Laboe pier and connected by telegraph with all the chief points of the defense. All these preparations were made within a few hours and without the slightest confusion.

"Meanwhile, at an early hour in the morning, the squadron of maneuvers had put to sea to gain intelligence of the enemy's movements, * * * and in the afternoon returned to its anchorage, as, a gale threatening, it could not spend the dark night off the port in the known vicinity of a strong torpedo flotilla. At dusk the wind was blowing half a gale and search lights were turned upon the channel below Friedrichsort. It was nearly midnight when the enemy's approach was signaled by rockets from the direction of Laboe. The Squadron of Evolution (the attackers) came within distance of the lower forts and engaged them furiously for a short time, disappearing finally to to the northwest. Surprise was expressed that no torpedo boat attack was made while the ships were occupying the general attention, and an impression prevailed that the weather was too bad for such small craft and that they had sought shelter. Just before two o'clock the Squadron of Evolution attacked again, more furiously even than before, and engaged not only Friedrichsort and the other forts in the narrows, but also the ships at anchor. Then through the smoke came the real attack by the torpedo fleet, which, steaming at a speed of 20 knots, got within 1,200 yards before it was discovered. A terrific fire was promptly opened upon it from everything that would bear, and it was forced to go about and make the best of its way to sea. But it tried the experiment twice again before relinquishing the contest."

It is evident that this attack was bound to fail. There seems to have been a labored attempt at a surprise by the torpedo fleet, but a heavy preliminary bombardment by battleships must certainly produce the opposite effect. It demonstrates, however, that the torpedo boat is the weapon of surprise, but that by unceasing vigilance and by properly controlled search lights a narrow channel will make their night operations of little avail.

In the English Naval Maneuvers of 1892 an interesting attack on the movable defenses of Belfast illustrated an excellent device for deceiving the enemy as to the position of the

mine field by means of a dummy mine field. The description is as follows:

"One feature of the operations carried on during the daylight of the 10th of August demands special mention, this being the loss by the Red side (the attackers) of one battleship, one cruiser and two torpedo vessels, all destroyed theoretically by crossing the mine-field, the actual position of which was not shown by any buoys or other surface marks over it.

"Of course no charges were used, and there does not appear to have been any suspicion on the Red side at the time these vessels had met with disaster. They had simply ventured in a little farther than others towards what looked like a belt of scattered casks and buoys extending across from the north shore of the lough, apparently marking the site of a mine-field guarded by a number of boats moving to and fro. The natural supposition was that persons stationed at the firing keys of the observation points on shore would be guided by the surface marks and would not fire any mines until a hostile vessel was seen among the buoys. As a matter of fact, the real mine-field, though apparently unmarked, was carefully charted, and no guesswork was necessary in the manipulation of the firing keys."

The laying of the countermines was successful and done under the cover of darkness and in spite of the efforts of the defense to prevent it by means of guard boats. The countermining boats worked under the protection of steam guard boats and two torpedo vessels, and under cover of the guns of their ships. The positions of these mines however, were too far away from those of the defense to accomplish anything—another victory for the dummy mine field. The blowing up of a vessel would have betrayed the position of the real field and that fact seems to indicate the wisdom of more than one series of mines. It was noticeable however, that a large squadron was held at bay by the menace of this unseen and dreaded force.

The French maneuvers of 1892 at Toulon and Brest are examples of the danger to an attacking fleet of a night attack on a well fortified harbor. At Brest where the entrance is long and narrow and fortified by many heavy guns, the forts must be reduced before the inner harbor can be reached. The attackers first sent in light cruisers and torpedo boats but these were soon discovered and driven out. The whole fleet in column then entered the harbor, at first with all lights screened, but afterwards using the electric search lights freely. During the entire attack the fleet was in full view of the gunners of the defense

while those on the ships were often blinded by the search lights from the shore. The attacking torpedo boats were easily found and driven off by the rapid firing guns of the defense, while the torpedo boats of the defense, hidden in the indentures of the shore were able to sally forth and use their torpedoes with sudden effect. A feature to be noted in these maneuvers was the preliminary attack or bombardment of signal and lookout stations. The fleet tactics were so faulty that no deductions of value can be made from them.

Actual war and earnestly executed peace maneuvers must be our guides. The navies are boldly showing us just what they will attempt against land defenses and the tactical means they will use to obtain success. Naval experts are trying their weapons on every possible field and against a variety of assumed foes. They aim to know the fighting value of every form of their material, the limits of its use and the most promising conditions for its activity. There is no secret about it and there should be no doubt in the mind of a commander of a defended harbor as to the nature of a hostile attempt against him so long as he keeps himself informed of the strength and composition of the force threatening his command.

THE PROBLEM OF HARBOR DEFENSE.

It is assumed as a basis on which to found a scientific defense of our sea-coast, that the forts and batteries in our defended harbors are of modern design, placed according to accepted tactical principles, and their armament approved by those who have to use it, in power, in mountings and in mechanical adjuncts; that all supplementary war material is ready and available at the points where it is to be used and suited in power and quantity to the needs of the harbor; that each harbor and fort commander has at hand a tabulated list of warships of all nations grouped according to values referred to the power of the guns of his batteries; that the study of such values and of the forms and vulnerability of ships is a part of the routine instruction of artillery officers; that there is a proper separation of the whole harbor into groups, including the moving defense, to conform to topographical conditions and the peculiar needs of the signal and submarine mine services; that, at the same time, these groups are united in turn into larger commands, the entire control to be exclusively the function of the highest military commander present; that the moving defense, when present, is to be, not an

aid by courtsey, but a military subdivision, controlled and directed by methods best suited to its possibilities and to intelligent and prompt cooperation.

Situated as above described, the first care of the harbor commander should be to prepare his plans to meet every possible form in which the attack may come, both by day and night, in fair weather and foul. If his defenses be adequate, then he knows the amount of interest which the object he protects offers to the enemy and the probable severity of an attack under normal conditions. The questions then recur; what will a fleet attempt? What can it do? What is doubtful?

The designs of the hostile naval commander will depend on the values of his ships, guns or other weapons, the topography of the harbor, the ultimate object of the attack and the relation of the attack to the strategic plan. With the last we have nothing to do in this paper so the first consideration is the vessel, the qualities and design of which and the character of the armament will decide her tactical position in the attack. The ship commander should know therefore:

1. The presentation of his ship which will offer the strongest offensive and defensive action.

2. The rate of speed best adapted to his weapons.

3. The range at which the ship's guns will inflict the greatest damage.

If the land commander knows the value placed by naval experts on the presentation, speed and range for fighting each class of ship and armament and has discovered the strength and character of the enemy moving against him, he holds the secret of their possible plans and the key to their probable tactical design.

1. The ideal unit in the naval line of battle is the battleship. The characteristic of her armament is heavy bow and stern fire, thus enabling such a ship to present a small target, which together with armor protection makes anchoring under fire possible. To these may be added, comparatively low speed and slow maneuvering, thus giving her but little advantage by being under way.

The protected cruiser with her heavy secondary batteries and numerous rapid-fire guns comes next in importance, it is peculiarly fitted for running past under fire and is no mean antagonist of barbette shore batteries. She is fairly protected against heavy fire whose duration is reduced to a minimum by her speed; and her destructive broadside, secondary battery and quick-firing

guns are of special value in keeping down fire from exposed forts. Her protection and speed enable her to present a broadside, thus developing her heaviest fire.

Ships other than those protected by armor, such as cruisers and corvettes, have but feeble protection against anything but secondary and machine gun fire, a balance being kept by increased speed and great coal endurance. Such vessels have small value when pitted against fortifications, except under the most favorable conditions, such as foggy weather, great breadth of channel and short exposure. They may, however, be so employed, but their presence need give no anxiety to disappearing guns.

Torpedo vessels and boats are for special service apart from the fire of any guns they may have and their functions will be spoken of later.

2. The comparatively slow, heavy fire of a battleship makes low speed most favorable for her, as great changes in range would more seriously interfere with the effectiveness of her fire than with the forts, her armor protection offsetting the added exposure.

The opposite considerations make fairly high speed necessary for the protected cruiser in her attack, although it would seem proper for her to anchor or run slowly when the fleet has a decided superiority in the power of artillery. In narrow channels, all maneuvering will be at reduced speed, for better control in turning and stopping.

3. The range to be selected for ships' guns will vary with the position of the shore batteries, the kind of armament on shore and the general design of the attack. If the forts have a great command, ships will keep as far away as possible. Exposed parapets will be attacked at moderate distances with shrapnel fire, especially by protected cruisers. In a bombardment, moderately long ranges will be taken, particularly if the protection of an island or point of land can be secured. Abroad, comparatively short ranges are insisted on (2,000 yards or less); but here, longer ranges are growing in favor in order to get the full value of the fire from heavy guns.

These general considerations will fix the value of an attack by single ships. The fort commander should then know what tactical combinations the fleet will form against him; but here arises the general question of the reason for a fleet's presence and what considerations would lead it to adopt a particular course.

A fleet appearing before a fortified harbor may design:

1. To blockade the port;
2. To bombard the city;
3. To run past the batteries;
4. To silence the forts and batteries by a naval attack;
5. To gain possession of the batteries by combined naval and land operations;
6. To secure or mask the forts by a land attack under the protection of a naval force.

1. *Blockading.*—When a fleet sets out on an unfriendly mission to the ports of its enemy, the class and number of tactical elements composing it would be decided by the nature of the work to be done. For extensive operations against fortified coasts, the naval force would consist of line-of-battle ships, squadrons composed of cruisers, corvettes, gun-vessels, tenders and torpedo vessels; and a semi-naval establishment of heavy wrecking tugs, surveying vessels to establish lights and buoys, launches, mining and counter-mining vessels, telegraph and cable laying vessels and search light vessels. The supply fleet will be made up of coal and ammunition vessels, commissariat and naval store-ships, hospital ships and floating repair shops. The preparation of a fleet for the close blockade of a port would be an indication to the harbor commander that a direct attack is regarded as inexpedient or the result doubtful. This should give confidence to the defense and increase its daring and activity. If the situation of the defenders be such that they cannot prevent the destruction of the blockader's objective by bombardment alone, the responsibility rests on those to whom the disposition of forts and batteries was intrusted.

To be effectual, the blockaders should absolutely control the ingress and egress of a port and dispositions made and maintained against any offensive attempt from the harbor to dislodge the blockading vessels. To accomplish this, the fleet will be divided into groups or squadrons, arranged in concentric circles about the blockaded port, the innermost line to be out of effective range from the shore. All the vessels except guard and special service boats will be anchored. At all times, scouting boats will be active, pushing in as close as possible to attack signal stations, mine and torpedo vessels when chances are favorable. At night certain ships will probably close in to bombard although this is regarded by certain authorities as harmless and expensive. Their essential duties will be to keep the defense on the strain of constant expectation and to give the appearance of increasing and fearless vigilance. Vessels at anchor will be protected by

triple booms and these in turn by guns and mines. At night special ships and boats will flash the electric light, but fixed beams, if sufficiently numerous to surround the fleet, are preferable. Unless the defense have an active naval auxiliary, the fleet will retain its day position during the night. A new feature in modern blockading will be a submarine telegraphic connection between the inner and outer vessels by which the enemy's movements may be made known throughout the fleet in the most rapid manner. The attack most to be feared by the fleet would come from torpedo boats, nor can it be said that a fleet, however carefully surrounded by barriers and the active protection of its own torpedo boats is wholly free from danger of serious loss from this quarter, if the enemy be daring and aggressive. It is plainly to the interests of the harbor commander to keep the blockaders on the alert and if possible force them out to sea at night. This subjects the personnel of the fleet to unusual and fatiguing efforts and adds the discomforts and dangers of off-shore weather.

2. *Bombardment.*—The bombardment of a city would take place only as a means of overcoming the armed resistance. This would be done either when such procedure would cause the surrender of the defenses by havoc in the town, or when the results of success might not be commensurate with possible loss in a direct attack on the defenses. In either case the fleet will anchor in such formation as to develop the heaviest fire and to obtain the greatest advantage from any dead spaces the shores may afford. In a heavily fortified harbor, protecting of course an important objective, a bombardment is possible only when the tactical dispositions of the land and moving batteries are faulty or when enough of the outer defense has been overcome to allow the attacker's fire to reach the city.

3. *The Run Past.*—The run past the batteries may be expected when the channel is clear or has been partly cleared from obstructions where it is fairly wide, say two miles, and defended by batteries of low command, and when the passage under fire is not too prolonged. Even though the run past the outer defenses, where there is usually plenty of sea room, be feasible, an attempt of this kind would probably not be made where inner defenses also must be met, and where the waters beyond do not afford immunity from fire. At night or in foggy weather these conditions need be less favorable to the attacker, but the channel must not be tortuous nor the currents strong and dangerous. The formation will be the single or double column or indented double column, depending on the width of the channel. If in double

column, the ships will not be closer than their maneuvering areas. As a preliminary there will be a systematic attack on the mine field so as to clear a passage broad enough for single ships, at least. If this be made in the daytime, (an exceptional situation, unless foggy) the heavy armored vessels will move up close to the mine field and engage the defending batteries. Torpedo boat attacks also may be expected on the mine defenses. Should the enemy fail here, the run past is impossible ; but if he succeed, nothing can prevent it save a strong harbor fleet or very unfavorable topographical conditions. If attempted at night or in dense weather the fleet will not close in until the obstructions are overcome. When the run past takes place only an insignificant fire need be expected from the ships, as their principal object is to bother the shore batteries by speed and concealment. The search lights of the fleet if used at all will be on special vessels ; for it has been found that when on fighting ships they are more disadvantageous to the ships than to the forts, under these circumstances, as they define the ships' exact positions and often interfere with the proper pointing of their own guns. The shore batteries may expect a close, hot but brief fire from rapid firing guns and guns of medium caliber. It has been found that the modern high power gun is not adapted for bombarding earth works. The object of the attack will be to keep down or lessen the fire of the forts by clearing the parapets, time being the principal element wanted. Many expedients, tricks and disguises must be expected by the defenders. Ships will change their rigging, color, general outline of their hulls, fill the harbor with a screen of smoke, creep in under the shadow of passing ships, work with speed, secrecy and silence, make false attacks both by bombardment and landing parties, mingle with the vessels of the defense, draw the fire of the forts by feints and other means for diverting the attention of the main defense from its real work and for concealing their own designs. Advantage will be taken of meteorological conditions and even that position of the sun most favorable for aiming will be selected.

4. *The Naval Attack.*—The attempt to silence the forts and batteries by a naval attack is the most serious of the purely naval problems: and like the front attack on land works by a land army is undertaken only when the odds are greatly in favor of the attacker or when victory is worth risks and sacrifices.

When the land defences are strong in numbers and construction and properly placed, the fleet in its attack will employ every weapon which it has at hand, each in its own sphere. The days

preceding the intended attack will be spent in careful surveys of the channels, gathering information about the kind and number of ships in the harbor, number, nature and grouping of forts and guns, strength of garrisons and their morale, positions of mine fields, batteries, position finding stations, search lights, torpedo stations, and in what way defended. This work will be extended into the harbor as far as possible under cover of light, swift cruisers and torpedo vessels. The nights will be employed in searching for mine-fields and in countermining, attacking signal stations, outlying batteries and showing activity at the harbor entrance sufficient to prevent torpedo boat enterprises or a surprise by the harbor squadron.

So long as an efficient mine-field is undestroyed, a strong attack will be impossible. Therefore the besiegers will bend their energy, skill and daring to overcome this obstruction. This once accomplished, even to the extent of a passage through the field large enough for a single ship, the obstruction is useless and may be destroyed quickly. The attack by the ships may be made in several formations, depending on the dimensions of the harbor, the breadth of the entrance, the depths of water in the vicinity of the points to be attacked and the distribution of the batteries.

These fighting formations are:

1. Narrow front and great depth, such as a single or double column.

2. Extended front with slight depth, such as a line or double line.

3. Front and depth equal, such as a square.

4. Groups in their several formations, such as, triangle, echelon, column, line.

In any formation, ships in the same column, line or group will keep as close to each other as their maneuvering areas will permit, a common interval being two cables (400 yards).

The period of a change of formation of a fleet is a time of weakness, and it is then that the batteries on shore might by a concentrated fire on some single vessel, preferably one slightly armored, throw the fleet into confusion, thereby destroy its cohesion and the unity of its efforts. This result is particularly to be feared by a fleet commander when his vessels advance in column.

A ship about to alter its course will create a screen of smoke by a broadside. The state and movement of the tide is a consideration, and history shows that vessels will seek to attack on

the ebb which enables them to keep head to their objective, gives them better steerage-way and carries disabled ships out of fire. Just how soon the fleet will open fire on shore batteries is undecided as are also the most available positions in the formations for the various types of vessels. It seems probable, however, that the fleet attack will be opened with a bombardment by the heavy battleships at anchor, at longe range, to cover the advance of the more lightly armored vessels which will try to get as close in as possible without being seen, to run by the outer batteries at high speed and then engage the main inner line. The topography of most harbors will compel the column formation for the fleet (the weakest of all for such attacks and dangerous at high speeds), the van of which will perhaps be the armored cruisers, because of their protection, their strong fore and aft fire (which can be used to drive off the opposing harbor ships) and their greater maneuvering handiness over the more powerful battleships.

So much depends on the physical conditions in a harbor and the distribution of the land batteries, that the exact tactical formation cannot be foretold, except for special situations. This we can know; that the fleet will concentrate its fire, as far as possible, on the key points, avoiding a separating or distribution of its ships. This it may do by a cross-pointing of its batteries or by passing the fleet in column before the point selected to be assailed. If the forts can be approached separately, as might be the case of outer batteries in a broad roadstead, they will be attacked in detail; but if they are so placed as to mutually support each other, the fleet will distribute its fire over all works within effective range so as to lessen the accuracy of the hostile fire.

The ships will undoubtedly attempt to anchor, should the conditions be at all favorable to this move, and every effort should be made to prevent it. A common formation in such a case would be an echeloned double column with the unarmored vessels in the outer column.

It is hardly possible that land batteries will meet with curved fire from a fleet, unless it have an especially equipped squadron for bombarding purposes—a form of sea attack possible only against a fleetless power. A recent attempt by certain naval powers, to place mortars or howitzers on fighting ships, need not be regarded seriously.

Modern rules for fighting ships, as deduced abroad, especially in attacks on forts, require them to engage at moderate ranges

so as to employ to the fullest advantage rapid firing guns using shrapnel, and machine guns. This of course does not modify the caution already made that ships will not approach close to batteries having very high command. Long range will be used for searching effect in order to annoy or demoralize the fort garrisons, rather than to avoid injury to the ships. In case of a mere bombardment, the results will not compensate for the risk of injury to ships of a fire at close range. If the defense be known to be weak, bombardment may commence underway, and if it appear possible to reduce the forts by a direct attack, the fleet will close in and anchor.

There is one very important factor which the land commander should bear in mind; and that is, the effect on the fighting men of a man-of-war of the nervous strain put upon them. The period of the struggle in which accurate firing, quick obedience, full comprehension of orders and intelligent discipline can be maintained is found to be comparatively short on the modern warship under a heavy fire. The effects of hostile shell are so far-reaching and so terrible; the combatants are so confined within the narrow dim lighted batteries, separated perhaps from most of their comrades and having no knowledge of what is being accomplished or what fate is overtaking them; these added to the knowledge that a single well placed, effective shot could send them all to the bottom with frightful suddenness, soon weaken the nerves, lessen the rapidity and accuracy of the ship's fire and introduce demoralization and confusion.

Therefore, in an attack of this kind, the land batteries should open early a concentrated, deliberate and carful fire, making every shot tell, if possible.

Torpedo boats would be used against the harbor vessels only and in a separate attack, attempting to keep this portion of the defense from interfering with the fleet's attack on the land batteries.

The naval maneuvers of 1891 in England and France seem to show that a fleet a long way from its base will not be accompanied by torpedo boats; that is to say, these boats will not form part of the permanent fleet. Their absence would add enormously to the importance of the harbor torpedo boats which in any case always have the advantage of the attackers boats by a knowledge of the coast, a safe harbor in bad weather and opportunities for repairs and a resupply of material and crews.

5. *Combined Naval and Land Operations.*—The war of the Rebellion furnished several notable examples of combined naval and land operations; but no particular tactical lessons for fleets can be drawn from them. Such operations usually indicate that the work cut out is too great for the power of the fleet alone and the burden of the fighting falls on the land forces. The tactical arrangement of the fleet would be that for a simple bombardment, the main object of the fire being a demoralization of the defenders.

6. *A Land Attack Under Protection of a Naval Force.*—In all probability such an attack would be made by a small fleet or a fleet whose ships were too vulnerable to the land guns. In any case, the fire from the ships will probably be from long range and their attack intended to occupy or distress the shore batteries in front while the landing party advances against a weaker side. The element of surprise will enter largely into the plans of the attacker. This form of attack might be expected against a fort well posted on the sea front, but weak on the land side, or when the harbor obstructions are unsurmountable, thus preventing a close fire by the fleet or a run past and an attack in rear. In any event, the land approaches must be comparatively unguarded. The weakest moments for the fleet in such an attack are during the disembarkation and landing, and advantage should be taken of the situation.

In this attempt to give what is believed to be the present accepted methods for naval attack on land works, it has been difficult to avoid invading the complimentary subject of the resistance of fortifications to the offensive power of ships. In bringing the two forces in contact the statement of an offensive move by one, naturally suggests the counter for the other; the fleet's peculiar qualities for attack, at once develop the needs of the fort; the special weaknesses of the ships point to opportunities for timely strokes by the land force. This paper is intended to be limited strictly to the naval attack, and its aim is to present as accurate a description as possible of what will take place in harbor waters before the eyes of fort commanders.

There is still much to be developed in naval tactics; and in the absence of authorized rules the criterion must be, the conduct of fleets in action, both in war and peace maneuvers, and the decisions of military critics of high professional standing.

In a mere outline such as this, it seems unnecessary to give reasons for tactical dispositions and values. There is no attempt at close analysis in this presentation, as it is designed to be but

a statement of the conclusions which thoughtful and experienced military men have drawn from their observation and study.

H. L. Hawthorne,
1st Lieutenant 1st Artillery.

THE TRAM-CHRONOGRAPH.

By FREDERICK J. SMITH, M. A., F. R. S.
Millard Lecturer in Experimental Mechanics and Engineering, Trinity College, and University Lecturer in Mechanics, Oxford.

The chronograph, described in this paper, was designed with a view to deal with the measurement of periods of time differing considerably in length, so that it might be used, either in physiological research or for measuring the high velocities of projectiles. The original instrument was used to determine the velocity of sound in different gases, and also in solids, such as steel rods.

A front view of the instrument is shown in Fig. I, a carriage c_1c_1 to the front of which is attached a sheet of smoked glass GG_1 runs on three grooved steel wheels which engage with two parallel steel rails RR_1 which are attached to an iron girder, supported on three standards $s_1s_2s_3$. These standards are fixed to a slab of slate, supported on brickwork. The top of the standard s_1 is furnished with a trihedral indentation, such as would be made by pressing the corner of a cube into any substance which would take its shape. The top of s_2 is a horizontal plane, and the top of s_3 is provided with a **V** groove pointing towards s_1. Three hemispherically ended screws, passing through the girder, rest on the standards, by this means the instrument is held in position.

The instrument may be removed from the standards and replaced in its original position at once. The method of support is similiar to that used by Lord Kelvin for determining the position of galvanometers, and it is known as the Hole, Slot and Plane method. The carriage is driven along the rails either by means of a falling weight, or by the piston P which is attached to two spiral springs, NN, this piston is held against the springs when extended by a catch and handle H.

The carriage is brought to rest by a brake B, made of a leather strap and a spiral spring, a projection at the back of the carriage runs under the strap, and it is thereby brought to rest quietly and without any jerk. The velocity of the carriage is usually from 10 to 12 feet per second. In front of the carriage stands a pillar M, this is also supported on the hole, slot and plane

method, the pillar carries a slide to which the electromagnetic-styli and standard tuning fork are attached. By means of this pillar and slide, several styli may be placed side by side, and a trace obtained from each. The pillar can be turned about a central axis, and the styli are adjustable in three directions at right angles to one another. To the back of the girder a contact key *K* is fixed, which is thrown over by a projection at the back of the carriage, as it passes.

Two sorts of keys are used, to suit the work in hand, either, a key which breaks the electric circuit or makes it. The wires from the experimental range are attached to the terminals *T* and to the current reverser *Q*.

The instrument is used thus; a piece of plate glass is slightly smoked over a wide gas-flame (the gas being passed over benzoline in a Wolff's bottle, to render it more full of carbon) it is then fixed to the carriage, and the carriage is brought up against the piston and retained in position by the catch and lever, the pillar is then turned round till it is arrested by a stop, then the styli are in line with the surface of the glass. After a signal has been received, that the gun is ready, the tuning fork is set in vibration, and the handle pulled over, the carriage on reaching the key fires the gun, and the styli mark the glass successively as wire or dutch metal screens are broken by the shot, the carriage is then again brought back, and the tuning fork trace is ruled through with a line made by the stylus of the fork when at rest, this breaks up the time trace into wave lengths which can be easily counted. The markings on the glass are then read by means of either the double square *AA* or the optical micrometer divider *DD*, Fig. II, when the rails and carriage (from which construction the instrument is known as the Tram Chronograph), are in adjustment, the uniformity of velocity of the carriage is such, that curve lengths representing the period of the tuning fork, on the time trace, at either end of the glass, which is usually eighteen inches long, are found to be of the same length. The spring end of the instrument is slightly tilted upwards, to compensate for friction due to the wheels.

After an experiment has been made, the glass, with its three or more traces, is removed from the carriage, and placed on a sloping desk of plate glass, inclined at about 60° to the horizontal, this enables the experimentalists to see the traces clearly, the double square *AA*, Fig. II, is then applied to the upper edge of of the glass (which is made straight by having been polished on a true plane) and the distances between successive styli markings,

are transferred to the time trace of the tuning fork, the points of intersection are marked with lines drawn at right angles to the traces with a scriber. The double square is furnished with a micrometer screw, so that it can be very exactly placed in position.

It has been found convenient, in powder works, where the instrument has been in constant use for some years, to retain records of experiments. Instead of the plate of glass, a metal plate is attached to the carriage of the chronograph, to this is fixed a sheet of hard glazed paper, prepared for the purpose, this is smoked in the same manner as the glass, the traces appear white on black, and they are set by passing the paper through a very dilute solution of photographic varnish in alcohol. The papers are dried, dated and numbered and kept in the form of a book for reference.

PRINTS OF TRACES ON GLASS.

The traces on glass may be easily printed on smooth bromide paper, thus, (without setting the smoked surface in any way) the bromide paper is placed on a soft support, such as a table cloth, and then the glass, smoked side downward, is lowered on to the paper, after the manner of closing a book, in this way the smoked surface is not injured; light is then thrown on to the traces from above for a few seconds, and the print is developed and fixed in the usual manner, and kept for reference.

THE OPTICAL MICROMETER DIVIDER.

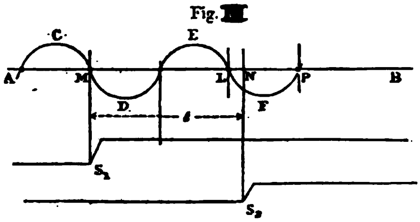
When very fine measurements are required, for example, when the velocity of sound in a steel bar is to be determined, then the fractional divifions of a period of a tuning fork trace must be read. The instrument is shown in Fig. II. The trace is placed on the stage *DD* below the microscope, and the length of one vibration period is determined, then the length of the fraction of a vibration length is also determined, and by simple proportion the time represented by the fractional length is deduced. The microscope is mounted on two geometric slides *A* and *B* and the whole system is balanced. The top slide is kept up against the micrometer screw by a spiral spring *s*, so that there is no back lash. The micrometer screw is 1^{mm} pitch and the micrometer head is 12^{cm} in diameter, so that small subdivisions of the m.m. are readily seen. o is a shifting zero mark, by means of this the zero can be easily reset without many rotations of the micrometer head. In ordinary working, the slide rule is used to reduce the values of the readings.

The trace, either of the tuning fork or of the electromagnetic styli, present a curious appearance under the microscope, a jagged road appears to be cut through the smoked surface by the aluminium points of the styli, but a central bright, thin line marks the position of the sharp point of the scriber. This line is always used for the purpose of time readings. When the microscope only is used for reading traces, a very slight smoking of the glass will be found sufficient to give good clear markings.

THE OPTICAL WEDGE DIVIDER.

When a tuning fork is used to determine the period of time between two chronograph markings, traces such as AB, S_1,S_2 (fig. III) are produced on a sheet of smoked glass, which is carried in

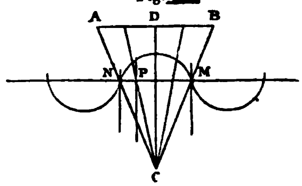
Fig. III



contact with the points of electromagnetic styli and the stylus of a tuning fork. In the figure, S_1S_2 are the markings of the electromagnetic styli, they show the beginning and ending of a time period; parallel lines ruled through S_1S_2 cut the fork trace at M, N. The central line AB is ruled through the curved trace CDEF by the stylus of the fork when at rest, in its position of equilibrium. Hitherto I have measured a length such as t, which is made up of one whole vibration ML and a fraction of a vibration LN, by means of a traversing micrometer-microscope, furnished with a spider's web, or a quartz fibre in the eye-piece. This method of determining the length of LN in terms of a vibration length, though very accurate, has the disadvantage of taking a considerable time to go through. By means of a device which I have called the Wedge Divider, this value may be accurately and quickly determined. A triangle (fig. IV) of which the sides AC, BC are equal is ruled on a piece of plate-glass; the base AB is divided into any number of equal parts, and each division is joined to C by straight lines. I usually divide AB into 100 parts, and each tenth line is dotted as well as ruled. To use the wedge divider, the trace is removed from the chronograph, and after being ruled, is varnished with very thin photographic varnish. The divider is then placed upon the trace with its ruled side in contact with the trace, and moved at right angles to the trace till

AC and BC cut the trace in N and M, the ends of a vibration or a half vibration length. Thus by similar triangles the length MN is divided into the same number of equal parts as AB. This being the case, any length such as NP can be at once compared with a length NM, and consequently the time value of the length NP. I find that for accuracy, the method compares very favorably with the micrometer method, while the abvantage in time of working is as about four to one. When a large number of determinations have to be reduced the question of time is important.

Fig. IV.



If a well made aluminium stylus draws a trace on a smoked glass surface, the trace when examined by a microscope appears to have a bright line situated midway in the cutting excavated by the stylus, this line is always used to measure from ; the edge of the trace is of no value, as its outline is usually rather like the teeth of a mason's saw. For many determinations, such as those of wave-motions in solids, it has been found convenient to use a fork having a period of $\frac{1}{500}$ second ; by using the wedge divider, $\frac{1}{50.000}$ second may be at once read. The surface velocity of the glass is arranged so that each vibration is about 0.8 centim. long. My first experiment, which led up to the wedge divider used in conjunction with a microscope, was to put a trace into a projection lantern, and measure the image on a cardboard screen carrying a triangle, divided as I have described. By using the wedge divider in close contact with the trace, in the field of a microscope, the distorsion inherent in the lantern method is eliminated.

TUNING FORKS AND THE METHOD OF THROWING THEM INTO VIBRATION.

All the tuning forks used in connection with the chronograph have been made by Kœnig of Paris, a set of four give a good range, their double vibrations per second, being 200, 500, 1000, 2000, when a slow motion of the carriage is required, a small heavy fly wheel, mounted on the carriage, is thrown into gear with the two upper wheels of the carriage, this gives a low and uniform velocity of traverse, such as is required in physiological research. The forks are thrown into vibration by friction produced in a way, somewhat similar to that produced by bowing

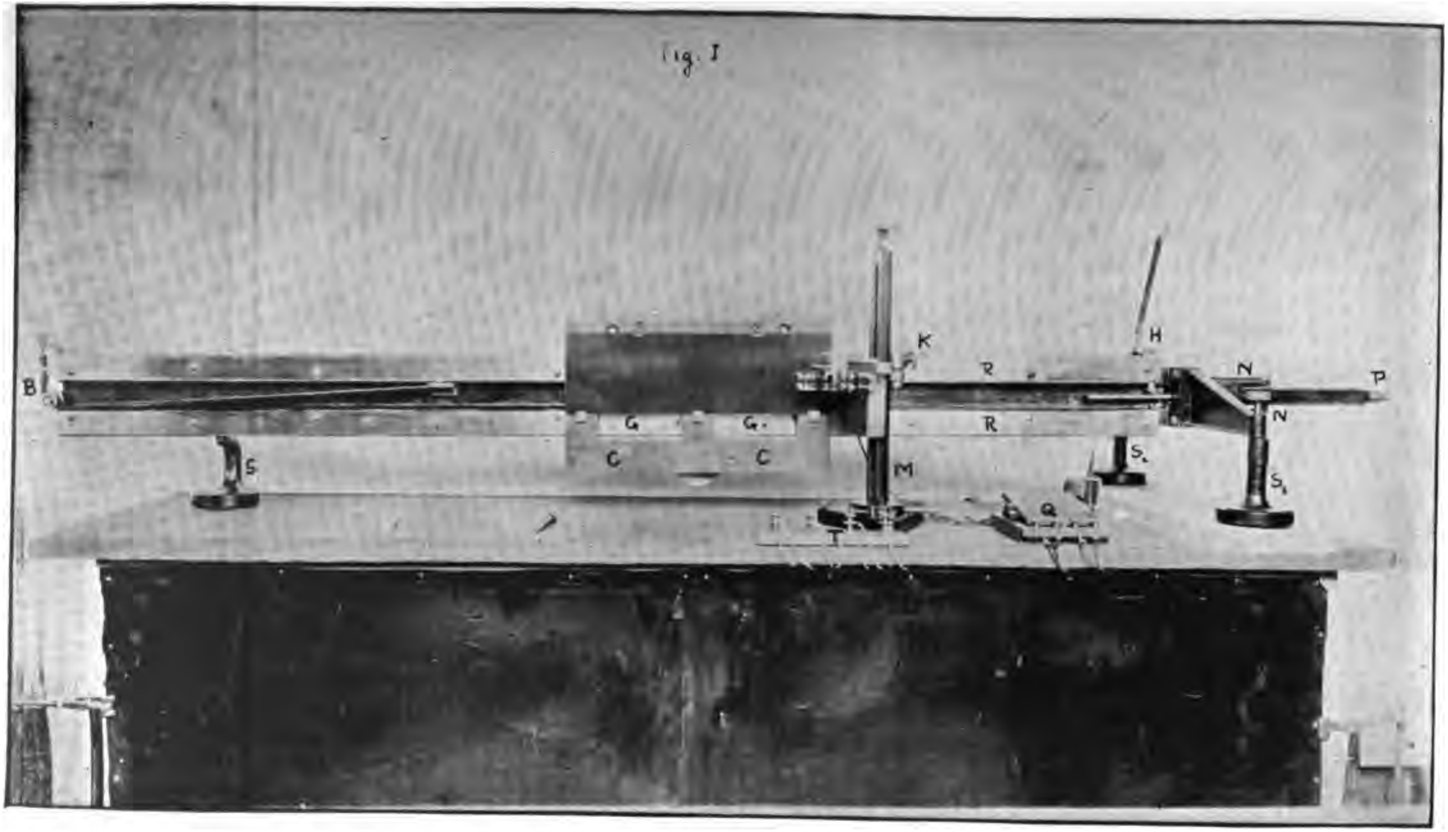


Fig. I

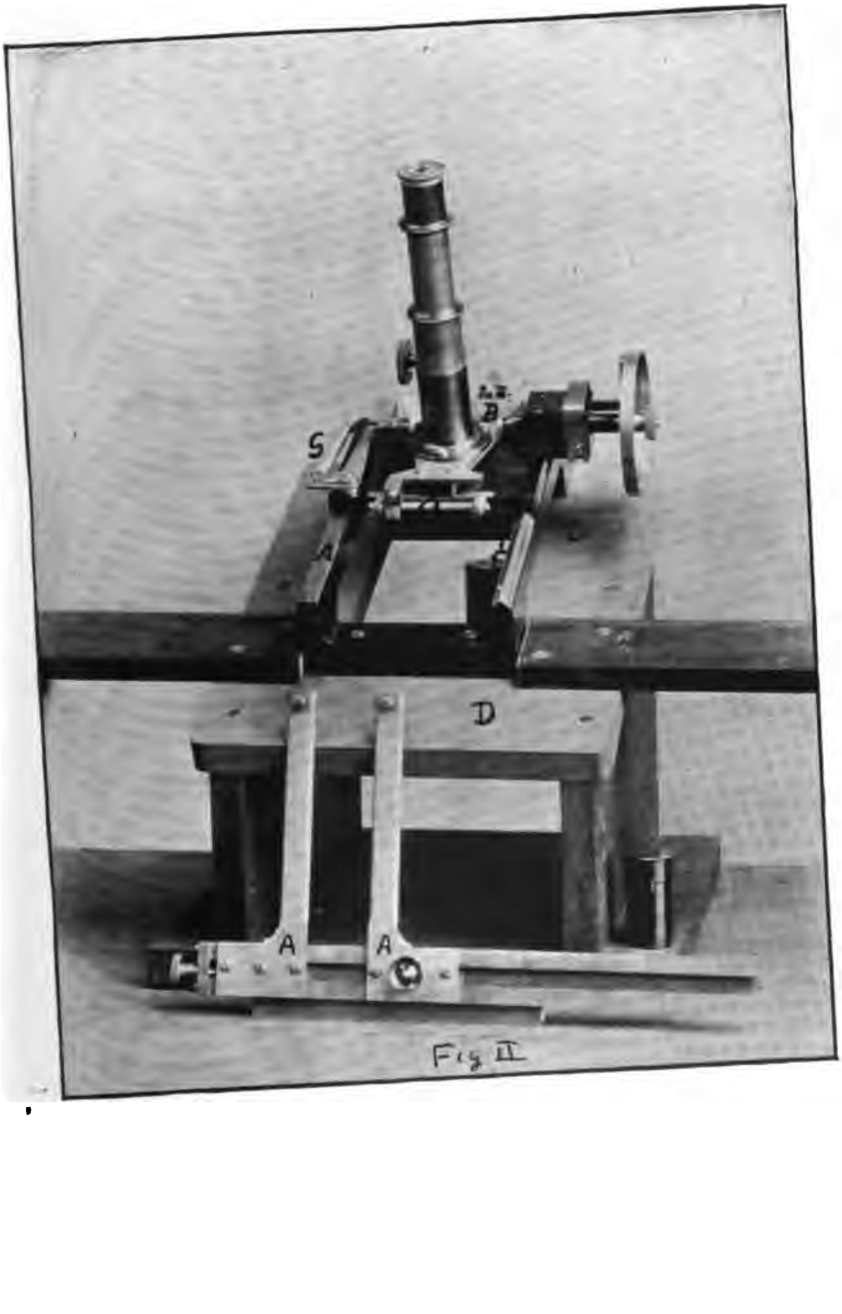


Fig II

with a violin bow. The edge of a revolving disc of leather charged with resin, is brought against the side of the fork for a few seconds, before an experiment, and then removed. All forks are calibrated, before being used, and their vibrations at any temperature deduced from the formula found by Professor McLeod (*Phil. Trans.*, 1880, p. 1, and *Proceedings of the Royal Society*, XXVI p. 157).

ELECTROMAGNETIC STYLI, AND MIRROR STYLI.

An electromagnetic stylus consists of an electromagnet carried on a support *I* (Fig. I) provided with a **T** shaped lever made of aluminium, this lever is furnished with a light armature, which is pressed away from the poles of the electromagnet by a steel grasshopper spring, the movement of the lever and scribing point with which it is terminated is limited by a set screw. The electromagnetic styli are attached to the pillar *M*, by means of geometric slides, by means of which exact adjustment can be easily obtained.

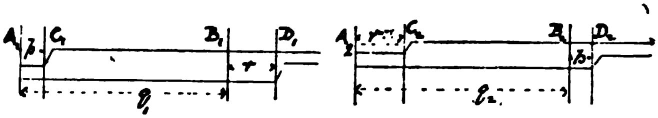
An electromagnetic stylus, to be of any value, must be constant in its action, that is, the period of time between the breaking of the circuit and the release of the armature should be constant. Exhaustive experiments on the subject of time lag, show that good results may be obtained from electromagnets when rightly proportioned, and styli made with electromagnets with small composite cores and very large yokes give excellent results. The ordinary electromagnet used in early chronography, in which the cores were large, had an enormous time lag, or "latency". This latency varies with the strength of the current used; if a current be changed from one value to a higher one, the latency does not at once return to its original value when the current is reduced. When two consecutive experiments of a similar kind can be made, the latency, when constant, may be eliminated by the following method.

LATENCY ELIMINATED.

When experiments can be made in pairs, the time between the experiments being short, latency may be eliminated thus, two traces are made, but the order in which the styli are used is reversed by an electrical commutator, the interchange of the styli causes the latencies to be cut out.

In the Fig. (V) suppose the real beginnings and endings of the two events to be on the lines A_1 and A_2, B_1 and B_2, let these lengths be called q_1 and q_2. Let C_1 and D_1 and C_2 and D_2 be the

FIG. V.



markings of the styli in the two traces, and let r and p be the latencies of the styli; then in the first experiment the observed period is:

$$q_1 - p + r$$

in the second

$$q_2 - r + p$$

by addition and division by 2

$$\frac{q_1 + q_2}{2}$$

is the mean value of the two readings, and the quantities r and p are cut out. It has been proved by exhaustive experiments that when the current used is kept constant the latencies remain constant. This method was always used by the author of this paper in the determination of the velocity of sound in different gases.

PHOTOGRAPHIC TRACES.

When instead of smoked glass, a photographic plate is used, the chronograph being placed in a dark room, then styli furnished with minute mirrors are used instead of those furnished with scribing points, and a ray of light takes the place of the mechancal scriber; this method was found to be of great value in the experiments alluded to on the velocity of sound.

PHOTOGRAPHY AND CHRONOGRAPHIC MEASUREMENTS.

By means of the following process, the chronographic traces are produced by light only (*Nature* vol. LIII, p. 206). Two sources of light at a suitable distance apart throw two beams of light on to a sensitive plate carried on the carriage of the chronograph. By means of lenses the beams of light are caused to form two sharp images on the plate in a vertical line, one above the other; a tuning fork trace is also made on the plate; the pressure of the stylus of the fork though slight gives a trace on development. If the plate traverses when the beams of light are not interrupted, two parallel black lines appear on development; but if during the passage of the plate, the beams are cut by any opaque object then two gaps appear, the interval between these markings, in terms of the fork trace gives the velocity of the object which cut the beams of light.

This process may be reversed, and the projectile may cut through opaque screens and so let light on to the photographic plate, I have found it convenient to bring the beams of light into exact position by means of mirrors (made of glass on which silver has been chemically deposited) attached to the pillar *M* Fig. I. During the process of adjustment, the plate is covered with a slide, on which the spots of light can be focussed, the slide is drawn away just before the experiment is made.

The trace of the tuning fork can also be easily photographed, a small piece of aluminium attached to the fork or the stylus of the tuning fork is pierced with a small hole and the image of this hole is thrown on to the plate by a lens; on development, a good clear trace is produced.

METHODS OF FIRING SMALL ARMS.

A small cylinder fitted with a plunger and packed with a cup leather, is so constructed that it can be readily placed between the trigger and the trigger guard; an air valve is fixed at *K* on the chronograph and is connected to the end of the cylinder by a metal tube, furnished with a piece of flexible tube for facility of adjustment; the air valve is also connected to a vessel containing air under pressure, usually fifty pounds per square inch. When the carriage of the chronograph knocks over a lever which opens the valve, the compressed air drives the plunger forward and fires the rifle; since the action of the air is not instantaneous the valve at *K* is placed a little nearer to *H* than the electrical key, the correct position is usually found after a couple of experiments. This pneumatic way of firing the rifle does not shake the rifle since the reaction is against the rifle itself, (Detonator pat. 1892).

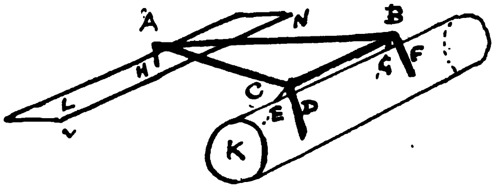
Another method often used by the author of this paper, is to make the body of the person firing the rifle, and the rifle itself parts of an electrical circuit, a slight induced current produced when the key *K* is knocked over, causes the hand to contract and fire the rifle, the rifle in either of these cases is supported on a stage or carrier. This method is not to be recommended in all cases as the expectation of the shock, frequently causes the agent to fire the rifle on hearing the click of the release lever of the chronograph. In the case of large guns the ordinary electric fuze is used.

NOTE ON THE GEOMETRIC SLIDE.

Throughout all the instruments described in this paper, the

geometric slide has been used, where traversing motion is required; it is easily made and perfect in its action. The principle is shown in a skeleton sketch Fig. (VI), where the triangle ABC

FIG. VI.



furnished with inverted **V** shaped legs ED and GF, and one leg H rides on the cylinder *K* and the horizontal plane *L*, the edge of which is parallel with the axis of the cylinder *K*. In this system the triangle and its legs can have only motion of translation, there are five points of contact, four on the cylinder and one on the plane.

When instruments are made on this principle small surfaces take the place of the points here shown. The pillar which carries the styli is provided with two similar geometric slides, which move parallel to one another and are kept in compression on the pillar by a spiral spring or india rubber washer. It would be out of place here to illustrate at length the large variety of ways in which this method of construction has been developed in connection with this and other instruments; the brief sketch of the system given will probably be sufficient to make the matter clear. I am greatly indebted to Mr. Elplinstone of Messrs. Elliott Bros. London, for the excellent manner in which he has produced instruments from my designs.

THE PRINCIPLES OF WAR.

BY COLMAR, FREIHERR VON DER GOLTZ.
ROYAL PRUSSIAN LIEUTENANT-GENERAL, IMPERIAL OTTOMAN FIELD MARSHAL AND ADJUTANT GENERAL.
Author of "The Nation in Arms", etc.

Translated from the German.

"War belongs neither to the domain of Art nor to that of Science, but to the domain of Social Life. It is a conflict involving large interests, carried on by the shedding of blood, wherein alone it is distinguished from other conflicts. It may be likened to trade, which is also a conflict of human interests and actions, rathei than to any Art, but it is much more closely related to State Policy, which may be regarded as a kind of Trade on a large scale. Moreover, State Policy is the womb from which war springs; in it its lineaments are already outlined, though they lie hidden from view, just as the characteristics of living beings are outlined in their embryos".

Clausewitz, *On War*, Book II, Chapter 3.

INTRODUCTION.

The conditions under which military operations are carried on differ so greatly one from another that it will be almost impossible to find any two situations exactly alike. But, even if this ever should happen, the persons called upon to direct these operations in the one or the other of these cases will still differ in character, and the subsequent movements will consequently never exactly agree or be quite conformable.

From this it follows that, although there may indeed be laws in the art of war indisputably correct and true, their application will by no means necessarily lead to the same or similar results, as would be the case in the application of two mathematical formulas. We say that it is only necessary to adapt them to the peculiar circumstances governing at the time, in order to insure success. But it is a very difficult matter to do this correctly.

The simple knowledge of the laws of the art of war is therefore of doubtful value. If the many circumstances and conditions, on which success in the application is dependent, are not clearly set forth, this knowledge may, as a matter of fact, lead to serious misconceptions and errors. It may easily induce an exaggerated idea of the power of the rules and regulations of the art of war to secure victory, and—what is even more dangerous—an overestimation of one's own genius or ability. It is a remarkable

fact, but one readily understood, that precisely in those armies, in which the leader has the least opportunity to try himself practically, the number is particularly great of those, who feel that they are capable of being commanders, and are quite satisfied that they can fill that position with honor.

Where the golden school of practice comes into play such views are rapidly rectified by failure and defeat. The barometer of self-confidence falls in that case, as on an approaching storm, to a lower level.

Many military institutions of high standing have, indeed, given up the idea of making the study of the theory of the art of war a special subject of instruction, and leave it entirely to the individual to acquire the fundamental principles thereof by the study of military history, by the careful observation of comprehensive maneuvers of troops, and by thoughtful reflection.

Nevertheless, the need of a brief discourse on the principles of war is undoubted. The young soldier who desires to prepare himself as a leader, will not always have the opportunity, working by himself, to reach his goal in the way indicated. Nor will he find everywhere that active intercourse with well-informed professional comrades, which offers the possibility of an intelligent exchange of thought and opinion, extending in time to the entire domain of war, and which will furnish him with a course of instruction without much effort on his part and without compulsion.

The novice, who, without the aid of a reliable guide and teacher, still desires to learn the laws of his art from books, finds himself, therefore, under the necessity of ascertaining as best he may what are the fundamental rules of action in the art of war, which are to be observed and followed. They may be determined by a comparative study of the older works, such as those of Bülow, Jomini, Clausewitz, Willisen, etc. But such a study requires time, labor, and a certain amount of preparation. The newer treatises on the art of war concern themselves principally with those conditions which began to play an important part only in our day, and did not formerly enter the problem at all, namely, the mobilization of the army and its concentration on the frontier. This is directly dependent on the existence of a dense network of railroads like that in western Europe, furnishing the means of a rapid concentration of the forces. Each nation attempts to surpass the others in this struggle. Since this process is merely the transportation of large masses of troops, the entire subject resolves itself into a kind of military mechanical process,

which furnishes an opportunity for him who is versed in the technicalities of his art to permit his brilliant qualites to shine, and as a result it is now considered in many quarters that the entire subject of the art of war is limited to this one small subdivision of it.

They forget that wars may be carried on in lands where the railroads do not as yet play so prominent a part as in western Europe, so that the concentration of the armies would be effected more slowly and in a simpler way. The fact is also overlooked that, even in western Europe the importance of railroads in actually moving the forces into position during the battles is after all not very great.

Now, the operations of the armies after their deployment is the very branch of the subject which we propose specially to consider here, because it is often treated in such a niggardly way. It is, and will ever be, the most important part of the art of war. The preparation of armies for war, and their concentration and supply constitute appropriate subjects for special treatises, admitting of extensive development. Here they will be considered only in so far as they may be necessary for a correct understanding of the whole.

If, in order to avoid adding another to the many bulky books on the subject already in the market, we refrain from setting forth a systematic development of the fundamental principles which we desire to present, there will be very little left for us to give besides a table of contents, so to speak, of a treatise on the art of war, nevertheless, this will be in conformity with the object proposed, namely, to direct the beginner, by easy steps, to a more thorough study of that art. Moreover, our book can fulfill its purpose of serving as a guide, which is the object we have proposed for it, only by this contraction in volume, in order that it may present, as fully as possible, in the comparatively limited number of hours of instruction in a year's course, a general view of the entire field of study.

Of course, we must ask the reader to accept for the present on faith many statements, the absolute correctness of which may appear to him doubtful. But, since it is only a question of putting him on the right road, where he may himself continue the study of the subject, no disadvantage resulting from this fact is to be feared. His further investigation will enable him to determine the circumstances under which, either conditionally or unconditionally, these assertions will hold.

To him who is already well informed this book may serve as

an *aide mémoire.* Clausewitz says very truly, that the great difficulty is to remain true, under the difficulties arising in war, to the fundamental principles which one has established. For this purpose it is above all essential to be able to recall them at the proper moment, and this requires that we call them to mind from time to time. But to accomplish this a "brief discourse on the principles of war" is a better aid than a philosophic military treatise in several volumes.

Certain subjects which are usually contained in writings like the present, such as security and information, the issuing and the execution of orders, etc., have been excluded. We have limited ourselves to a presentation of the fundamental principles of utilizing the forces available, which find application in war. The art of actually applying these principles will be discussed in another work, which will appear later and in which we propose to take into account everything that concerns the relations of the commander-in-chief to his army. This division has the advantage of avoiding the apparent contradictions between rules of action and their application. For example, we may very properly, in a general treatise on the art of war, advocate the *offensive* as decidedly the more advantageous, and yet, in the case of a particular army and under particular circumstances, choose the *defensive* as the only correct method to be adopted. Were we to consider both subdivisions in the same treatise we would be obliged to add to every rule or maxim all the exceptions, and this would give an impression of indefiniteness and uncertainty, which would serve only to perplex the student. It is therefore better to present in a special treatise on the principles of strategy the necessary directions for the application of the rules set forth in these principles of war.

Certain exceptions to this were, however, unavoidable. For instance, the plan of operations, although more properly belonging to the domain of strategy is discussed here, because it is intimately connected with the concentration of the armies, and the same is true of the base of operations, the lines of operation and the lines of communication. The separation in these cases could not well be carried out.

I. THE POSITION OF WAR IN OUR SOCIAL LIFE.

The governments of all civilized nations maintain at present special ministers and permanent diplomatic missions for the purpose of regulating their political relations with one another, and

a large part of their work consists in settling in a peaceable way matters of dispute constantly arising.

But it will probably never be possible to entirely avoid cases in which each of the disputants believes it to be impossible to yield to the other without inflicting on himself a death-blow. Such cases have arisen in our own day from the efforts of nations to build up independent states, which it was impossible to accomplish without destroying the existing state of affairs. But even questions of power and influence, or of purely national jealousy and rivalry, may acquire such importance that political wisdom and diplomatic art might seek in vain for a peaceable solution. In that event a forcible solution by war becomes unavoidable.

War is, therefore, the continuation of state policy; the means used for attaining the object sought have been changed,—that is all.

The idea of making war impossible by means of courts of arbitration has not led to any practical results, because the power to enforce the decisions of such courts, to cause their general and unquestioned recognition, is wanting.

The best means of preserving peace are energetic war preparations; for the strong are less liable to be attacked than the weak. With the increase in the strength and power of armies the destruction resulting from their collision grows more awful; the responsibility of deciding upon a resort to war becomes more serious, and such a decision is consequently less readily reached.

Nations that are weak from a military point of view, and situated in the midst of stronger neighbors, are therefore in danger of war. Those which, from mistaken notions, neglect their preparation for war, invite this danger by their own fault.

The same is true of states with a lax government, which is not capable of controlling the passions of the populace; for the masses, once stirred into action, will be much readier to raise the war-cry than the cabinet.

The best preparation for war is such as makes all the intellectual and material means at the disposal of the country available for the successful termination of any war that may arise. A nation is not justified in trying to defend itself with only a part of its forces, when it is a question of national existence. The general methods of preparation for war, as well as the

details, depend largely on the internal conditions obtaining in the country, as well as on the international emulation existing at the time. They alter with the gradual changes in the social life and condition of the peoples.

The form under which preparation for war most generally appears in our day is that of the so-called "skeleton army," or, in other words, universal service. A part of the men capable of service are kept together in permanent organizations, which constitute the military school for the entire able-bodied male population and furnish the skeleton which in time of war is filled out by the instructed soldiers of the nation. Only a few of the states have done differently and organized a militia reserve, in which no standing skeletons, with the exception of a few instruction cadres, exist. Such a measure is justifiable when the natural position of the country makes an attack by a well-prepared army impossible, or, when the limited extent of a country, or the small number of the inhabitants, admits of this means of readily bringing to the front an army considerable at least in numbers.

The volunteer recruiting system finds application only very exceptionally, and is fast disappearing entirely.

2. DISTINCTIVE NATURE OF MODERN WAR.

To-day war always assumes its natural proportions, that is, a bloody contest between peoples, in which each side strives to effect the complete overthrow, and, if possible, the annihilation of its adversary.

The attempt will no longer succeed to so intimidate the enemy by the mere movements of masses of troops, and the taking up of threatening positions, as to force him to conform to our will, or as a well-known military writer expressed it at the beginning of this century "to secure victory without battle by the simple power of maneuver." The experience of the Napoleonic wars taught the world that such a method loses all effectiveness at once, if the adversary makes up his mind to go to work in earnest and strike out boldly in defence of his country. Moreover, it is impossible to-day to conceive of wars into which the belligerents do not enter with their entire available strength, or in which they do not purpose the complete overthrow of the adversary, but intend to put in only a portion of their forces, and pro-

ceed to a certain point, the attainment of which is all they desire.* Such wars are as impossible to conceive of as armed conflicts without the final arbitrament of arms. Such a course is rationally conceivable only in case the object of the dispute is a trifling one. But such an object will hardly lead to war at all nowadays. Nevertheless, should war take place as a consequence of perverted measures on the part of the belligerent governments, the national feeling of the people, which would be aroused, would at once come into play and would not permit those in power to rest the fate of the entire war on the success or defeat of a small portion of its war power. Public opinion will demand a strengthening of the forces, the adversary in turn will strengthen his, and so little by little, contrary to the original intention, the entire war power will be ultimately applied. Ever since states and nations have come to protect themselves against nearly every form of aggression, they have resembled persons who would rather lose their lives than their honor.

It follows, therefore, that the idea, so often expressed, of a methodical mode of conducting war, in which the entire war power is, indeed, held in readiness, but not made use of for an actual contest by arms, the effect being sought by a system of maneuvers and blows dealt by only a part of the forces, rests on a false conception of the manner of carrying on war at the present day. Only a very inexperienced and inactive adversary would allow himself to be delayed for a moment by such maneuvers. As wars originating in mere love of warfare, in the desire for plunder or the conquest of territory, have become impossible on account of the progress of civilization, and since this civilization suffers by every war, a belligerent must endeavor to force his adversary as rapidly as possible to an acceptance of the peace conditions. Since this is, however, not possible until one of the parties has lost all hope of successful resistance, so here again is exemplified the necessity for overthrowing or annihilating the adversary.

As long as the principle of nationality remains the predominant feature in the political structure this condition will obtain, and war will retain its natural proportions.

However, we must not consider this overpowering or annihilat-

* We except, of course, special cases, where, for example, a weaker state has infringed on the rights of a stronger, and in blind passion or from other cause remains deaf to its complaints, so that the latter is compelled as a last resort to take up arms in order to compel the proper adjustment of the matter in dispute. Such wars resemble executions in law, and are not included in the subject under consideration here. Colonial wars are also excepted, as they bring up special relations varying with the character of the country and of the enemy to be dealt with. Both these cases can the more readily be omitted, as the correct application of the fundamental principles of the art of war, as far as they are concerned, is of comparatively little moment.

ing as an actual killing or disabling of all the hostile forces. The defeat of a portion will as a rule make such an impression on the whole that the latter will probably lose hope and give up the contest. Hence, moral effect as a disturbing power must be added to the effect of weapons of war; indeed, human nature is such that this has its effect from the very first.

Therefore, when we speak of overpowering the adversary we mean compelling him, by destroying a portion of his army, to give up entirely all idea of any further resort to arms in the hope that it may be more fortunate; and by "giving up" we mean to imply that he finds himself placed in a position, such that, physically and morally, he feels himself for the time being unable to continue the war.

3. CHARACTERISTIC FEATURES OF MODERN WAR.

The adversary, who must be regarded as influenced by the same motives as we are, will probably concentrate his troops in a single army, so as to be able to strike decisive blows with his united power.

When, on account of the great number of the troops of the country, the subdivision of the army into a number of groups becomes necessary, inasmuch as the entire mass united in a single body might be entirely too unwieldy, several of these groups would nevertheless be united for any concerted action. There will always be recognizable a portion of the army which is intended to strike the decisive blows in the campaign, and which we may designate as the "main army". This embodies the main resisting power, which must be confronted. It is evident that, should this main army be beaten, the weaker groups remaining could hardly count on victory any longer. Indeed, they would probably give up all idea of further resistance, and we may thus be able, by accomplishing this one great result, to bring our whole work to a happy conclusion. It follows, therefore, that the first object, against which we must direct all our efforts, is *the enemy's main army*.

This first fundamental principle of the modern mode of conducting war does not imply that there may not be a number of minor operations preceeding the great clash of arms. Fortifications on the border, closing the main roads, may prevent the simultaneous movement of large bodies of troops. They must, therefore, be attacked and taken before the principal action begins. Both belligerents may attempt, by means of subdivisions rapidly thrown out to the front—masses of cavalry, for example

—to prevent the cencentration of the adversary's forces, out of which preliminary skirmishes and battles may develop.

But in these separate isolated actions no immediate object is attained; they are directly connected, both by the object to be attained and its result, with the main action and are a part of it, just as the lightning is a part of the approaching storm.

The surest means of defeating the enemy's main army is to unite a superior force against it; for, we cannot assume, in a general discussion of the subject, that we have the better leader at the head of our army, or that our army is braver than the enemy's. Such questions may, however, be taken into consideration in the practical solution of problems arising in actual war. But a scientific investigation must assume troops of equal value on both sides, except where an exceptional case is specially considered. That being the case it is evident that the decisive factor, next after the appropriateness of the dispositions, is the number of men brought into action.

From this we deduce a second general principle of the modern mode of conducting war, namely to bring together at the decisive moment, if possible, *all* available force. A single battalion may turn the scale at the end of the engagement.

It would appear, therefore, that detaching any troops from the main army must be a mistake. Inasmuch as the more important results practically determine and include the less important, we might disregard any minor danger, and even afford to bear some losses, provided we do not weaken our main army. But, as a matter of fact, this idea cannot be carried out to the extreme. Very seldom can the moment when the crisis is to be expected be accurately foreseen, and all the operations of secondary importance cannot very well be postponed indefinitely. Moreover, in every campaign there will be points, although out of the direct road to our main objective, the possession of which by the enemy may nevertheless have an influence on the movements of our main army, and at the critical moment interfere with its action. We are therefore compelled to secure such points by means of special detachments. Detachments are, indeed, unavoidable, and it is only a question of so making them, that they may be called in afterwards in time to take part in the battle, or that they may contribute directly to its successful issue. The most effective way of accomplishing the latter purpose is to have them hold in check, at a distance for the battle field, a stronger force of the enemy. Every detachment, however,

which has no relation whatever to the issue of the main struggle, is undoubtedly a mistake.

The concentration of very large bodies of troops at a single point naturally causes much hardship among them, and, in case unfortunate accidents like epidemic diseases ensue, may become extremely dangerous. When large bodies are concentrated, it becomes impossible to quarter all the troops in inhabited towns, and their maintenance and supply becomes uncertain and detective. Moreover, it is more difficult to set such masses in motion if, instead of being stationed in separate groups, they are concentrated in a single place, for, from two or more separate points of departure we can naturally find a greater number of available roads for troops to march over than from a single such point. On the march this difficulty will recur at every halting place for the night, and at every start in the morning. We must also bear in mind the fact that only from thirty thousand to forty thousand men can be marched on a single road, if we wish to unite the entire mass in one day on the battle field. Otherwise the subdivisions in rear will not be able to reach the battle field till late in the day. This circumstance, therefore, irrespective of those previously mentioned, enforces a subdivision of large masses, and the principle ot keeping our forces united must not be understood to mean literally that they are to march and camp united, but merely so that we can concentrate them at decisive moments, or at least sufficiently so for effective concerted action.

The art of war of to-day, therefore, consists of a continual separation and concentration of the masses. It is the duty of the commander-in-chief to preserve the state of separation (as that conducing most to the comfort of the men and alleviating the life of the soldier) as long as possible, at the same time taking care to insure the possibility of concentration when the proper time arrives. "No general rules can be given on this matter, the problem becomes a different one in every case."* The triumph of the art of separating and uniting would be to have all available forces united on the decisive day, without their having suffered previously on account of too close crowding together.

The mere continuation of the state of war, on account of the extreme sensitiveness of the present highly developed state of

* Field Marshal Moltke in *Militär-Wochenblatt*, November 18, 1867.—Napoleon has given us a clue to the solution of this problem, which we will do well to take to heart: A commander-in-chief should several times daily assume that the enemy appears in his front, or on either flank of his army, and then consider what is to be done. If he is at all in doubt it indicates that there is some error in his dispositions and he should at once proceed to rectify it.

commercial intercourse, has in itself become an independent disturbing and destroying power, which may under certain circumstances exert a deciding influence.

It follows, therefore, that to-day war implies an uninterrupted series of operations. A pause may occur occasionally, it is true, as when, for example, one of the belligerent parties after repelling the other is not strong enough to attack in turn. Indeed, this occurred in the last Turko-Russian war, after the second battle of Plevna, in which case the suspension of active operations lasted up to the fall of this place, four months later. In this particular case, however, the relative strength of the two sides was abnormal from the beginning. Turkey, being too weak of herself to follow up a successful repulsion of the invader, should not have declared war without the assured assistance of her allies. An original mistake, therefore, in resorting to war led to the exception in this case, and the result merely proved the rule. The long periods of repose, without any apparent cause, as we find them in the older wars, or such as sprang from a natural tendency to inaction, or in some cases from a mere habit, like that of going into winter quarters, are no longer possible. The cost of maintenance of the armies put into the field to-day is so great that simply to get rid of this great burden, if for no other reason, the governments concerned will insist upon the uninterrupted employment of the forces by the commanders-in chief.

The nation which can the longer endure a state of war has a great advantage. In this connection the case is readily conceivable of a power which, after annihilating the organized army of another, and overrunning the greater part of its domain, cannot endure for a sufficient length of time the sacrifices which this occupation of the country requires of it, and is in the end compelled to grant the defeated nation a comparatively advantageous peace.

This is generally lost sight of, and the annihilation of the enemy's principal army is erroneously held to be equivalent to the attainment of the object of the war.

Countries of large extent, like the Russian Empire, with a population closely bound together by strong national ties, living in not too crowded a state, and whose wants are simple, and who are therefore little dependent on an uninterrupted current of international intercourse, naturally suffer much less from a state of war then highly civilized states within narrow confines, having dense populations and lacking, as a nation, absolute unanimity or homogenity. The effect of these elements of weakness is

often increased by the fact that such states are not capable of supplying the wants of their population by their own produce, but are dependent on importations from other countries, which may be seriously affected by the war or even entirely cut off by it.

Again, social and political relations often play an important part. If the burden of war falls upon a simple peasant community, living scattered over a flat country, the government generally retains its freedom of action unhampered; because the individual has not in this case the means to give adequate expression to his desire for peace. But it is very different with the rich commercially active burgher class, congregated in large cities, who may lose their all by a disturbance of the ordinary state of affairs. They will be the first to cry for peace after any early defeats; and they possess, as a rule, by their control of the press, and through influences of all kinds, the means to enforce their desires.

Only among nations of approximately like civilizations, will the defeat of the main army carry with it the further consequence of compelling the much desired peace. A striking example of this is found in the campaign of Prussia against Austria in 1866, in which the war was decided at the battle of Königgrätz. But even under these circumstances events may turn out quite differently, as was the case in the Franco-German war of 1870-71. After the almost complete annihilation of the organized French forces in the first three months of the war, it required three more months to convince the French populace of the necessity of making peace.

In case of an intrinsic difference in the character of the nations carrying on a war the defeat of the forces and the concluding of peace will seldom be coincident.

Napoleon in 1812 did not fail because he could not defeat the Russian army, but because the defeat of this army and even the loss of the capital, Moscow, could not force the stubborn Russians, widely scattered over their immense extent of country, and difficult to strike in a vital point, to make peace. In the great American war the armies of the Secessionists were victorious almost to the last, but finally had to succumb, because at no time were they able to make such an impression on the Union people as to force them to make peace.

Therefore, after the destruction of the hostile main army, it is necessary in many cases to take up the distinct, and in general much more difficult problem of enforcing peace, the solution of

which, however, is usually carefully considered before war is decided upon.

We must determine, especially, whether our army, after victory on the battle field, is capable of making the hostile country feel the burden of war to such a degree that the desire for peace will outweigh the inclination to carry on the war. This is the point on which Napoleon I. failed. The organization of his forces was not sufficiently complete to enable him to follow up with constant supplies of fresh troops, the grand army engaged with the Russian army, that he might thus occupy the enemy's domain, already overrun by the advance, in sufficient strength to render its recapture in a reasonable time impossible. Had the Emperor been able to do this, he would have secured the desired peace.

The means to be used, in order to bring to bear the pressure necessary to awaken the requisite desire for peace, will depend on the nature of the country and the character of the people. The taking of the capital, perhaps even the theatening of it, as in the last Turko-Russian war and the war of 1828 and 1829, may suffice. But it may become necessary to seize the harbors, marts, the principal commercial routes, fortifications and arsenals for military supplies, indeed, all important establishments necessary for the existence of the people and the army; even the seizure of an important part of the domain of the enemy, or perhaps the entire domain, may be necessary. At the same time, should the subsistence of the population meet with difficulties, it will be sufficient to cut the country off from the outer world, as the Union succeeded very effectually in doing with the southern states in the American war.

After victory the desire simply for peace predominates and alters the character of the war. The attention given to the preservation of our own strength will from that time on be more pronounced than it had been previously. Henceforth it will be more a question of the duration than of the intensity of the strain. The Franco-German war clearly marks these two epochs. It opened with an energetic advance of the attacker, from one decisive battle to another, to a complete subjugation of the defender, and closed with a defense of the occupied district against the efforts of the defeated party to recover his lost territory. Peace was looked for, not from any further victories in the field, but from the fall of the besieged capital.

The characteristic features of the modern mode of conducting war may then be summed up as follows:

An *assembling* of all the available forces of the country, so that after victory an advantageous peace may be at once extorted.

A *mobilizing* of all the available forces at the very opening of the war.

An *advancing* without pause until the organized strength of the adversary is broken in a series of decisive battles, and then up to the conclusion of peace proceeding more quietly, and with greater care to economize the war power.

Naturally, during the latter stage, political measures, which brought forth the war in the first place, again come into prominence, and finally at the conclusion of the treaty of peace stand once more in the foreground.

4. THE PRINCIPAL METHODS OF CONDUCTING WAR.

We generally distinguish between attack and defense as the principal methods of conducting war, and designate as attacker that belligerent who decides to advance and seek the enemy, and if possible defeat him, and thus compel him to submit; while the defender is occupied with warding off these efforts directed against him.

He who thinks merely of defense, however, can at best only prevent his own defeat. The result is negative; he merely thwarts the efforts of the adversary. The defense is therefore not a complete method for attaining the object sought, viz: to overthrow the enemy. All advocates of the defensive, therefore, recommend in the end a counter attack. They acknowledge that to accomplish anything this method must after all be abandoned. Hence, the defense appears as a passing phase in the action of the commander, and only very exceptionally would this method be adhered to from the beginning to the end of the war. Only a commander who feels himself too weak to do otherwise would adopt this method, satisfied to ward off the destruction which threatens him.

In war therefore it does not necessarily follow that there is in every case a defender and an attacker. On the contrary, both belligerents, in case they are nearly equally strong and both conscious of their strength, will probably advance simultaneously to the attack. There will consequently be two attackers at the beginning, and this state of affairs will last until one of them has his strength broken in the early battles, or his hopes defeated, sufficiently to force him to concern himself with defensive meas-

ures. Often greater celerity and skill in mobilization and the consequent unexpected appearance of superior numbers will force one of the parties to adopt the defensive, as happened to the French in 1870. Considering the care with which the military strength of a prospective adversary, and the time required for the mobilization of his forces, are calculated nowadays, such surprises will probably be quite exceptional hereafter.

The attacker, while preparing for a concentrated effort, or with a view to economize his forces at one point, in order to be stronger at another, will often temporarily make use of the defensive as an auxiliary.

From all this it is evident that the defensive is the subordinate of the two methods of conducting war, and, in truth, it must be regarded as in itself incomplete.

However, it is convenient to accept the division as made, and to admit attack and defense to be methods of equal value. Each of these words designates the rôle of the respective parties, as well as the general dispositions of their troops, so that we are enabled to form a clearer picture of their appearance and the conditions under which they are acting, than if we had referred to them merely in general terms as being belligerents.

But it must be remembered that by attacker we mean the side whose line of action is principally attacking, and by defender the one who devotes his attention mainly to warding off the adversary. We must not imagine that the one constantly attacks, while the other continually defends.

The entire subject of the art of war may be divided into *strategy* and *tactics*. In general the former deals with the larger measures, the object of which is to have the troops enter the contest of arms under the most favorable conditions; while tactics comprises all the measures for this contest itself.

Strategy may also be called the art of leading armies, tactics the art of troop-leading.

Innumerable explanations and illustrations of these subdivisions have been given, but our conception of them is nevertheless not perfectly definite because the line of demarcation cannot be accurately established. Clausewitz defines tactics as the art of using troops in battle; strategy as the art of using battles in war.* This agrees sufficiently well with what has been stated above, and will enable us to obtain a good general idea of these two branches.

* Clausewitz. *On War.* I. p. 89 (fourth edition).

Moreover, this division of the general subject is advantageous as it enables us to indicate by a single word the kind of action referred to; it aids us also in obtaining a clear conception of the domain embraced by the study of the art of war, and it is well to preserve this distinction between the two branches, notwithstanding the fact that the strategical and tactical often graduate into each other.

We speak of strategical and of tactical attack, of strategical and of tactical defense.

Combinations of various kinds occur and will be considered separately.

In the first place strategical and tactical attack may be combined, as when an army advances to the attack in the theatre of war,* and then when it meets the enemy, also takes up the attack on the battle-field. Again tactical defense may follow strategical attack, when, for example, after advancing until we are in contact with the adversary, we then permit him to become the attacker on the battle-field.

In this case the adversary would be in a condition which may be designated as strategically defensive and tactically offensive. He permits his enemy to complete his movements, awaits him, and when he appears before him takes up the attack.

A strategical and tactical defense is a purely passive state, consisting in awaiting not only the enemy's movements, but also his attack on the battle-field, being occupied merely with repelling his attacks.

Willisen in his Theory of the Art of War (*Theorie des grossen Krieges*) has arranged in a table all the possible practical results to be expected from each of the various combinations in case of victory or defeat.† Such mathematical computations are of doubtful value in the study of war; they are apt to give rise to false hopes and inspire false confidence. War is full of accidents and unexpected circumstances, which may exert a decisive influence on the events, and increase or lessen their effect, often causing the most careful calculations to be entirely upset. Uncertainty and insecurity are inseparable from war.

When Frederick the Great advanced to the battle of Kolin, to cover the siege of Prague, he found himself in a strategically defensive position, but on the battle-field passed to the offensive.

* It is necessary to state, however, that an army advancing for several marches is not always to be regarded as taking the offensive. The object of the movement may be entirely negative, in that the defender, having decided to await the adversary's movements may not wish to do this on unfavorable ground, and so seeks better conditions, or in that he cannot take station in too close proximity to some point which he desires to defend strategically and tactically. The general dispositions will always be the criterion of the character of the war on either side.

† See foot-note, page 45.

According to Willisen, were he defeated, under these circumstances, he should have expected to "retreat and then pass again to the tactical offensive." But his losses on the field and the demoralization of his troops, particularly of his infantry, were so great that a strategical retreat followed instead, and a complete change in the whole military situation.

Nevertheless, the table shows clearly that the greatest results, the annihilation of the enemy and the conquest of his territory, can come only from a combination of the strategical and the tactical attack, while strategical and tactical defense, even under the most favorable circumstances give but indecisive results.

Text-books containing discussions of the advantages and disadvantages of attack and defense, often give the impression that the character of the war in this respect is a matter of choice with the commander-in-chief. This is hardly ever the case; on the contrary, the character of the war is generally determined by the necessities of the case, which lay down the law for his action.

It must not be forgotten that war springs from state policy and is a continuation of it; therefore, the question of a strategically offensive or defensive war depends directly on the political measures preceding, and these are a natural consequence of historical events.

This is clearly apparent among the ancients. For example, in the wars of the Persians and Greeks, the changes in strategy correspond directly with those in history. A people which, in the course of its historical development, has reached a period of repose, or is perhaps declining, will not as a rule adopt the offensive in its state policy and will consequently go to war only when forced. Hence it is evident that it will usually await attack, or in other words will limit itself to strategic defense, followed by tactical defense.

See † page 44.

Method employed.	RESULT.	
	Victory.	Defeat.
a.—Strategical defensive and tactical defensive.	Indecisive.	Annihilation and loss of territory.
b.—Strategical defensive and tactical offensive.	No results for the entire campaign or war.	Retreat, and another tactically offensive moment.
c.—Strategical offensive and tactical defensive.	Advantageous general position, without definite result, as the enemy is still active.	Consequences averted by a favorable strategical position.
d.—Strategical offensive and tactical offensive.	Annihilation of the enemy; conquest of the teritory.	Temporary suspension of operations.

On the other hand, nations and states striving earnestly to advance their own interests, never lack in political objects, in pursuing which their state policy takes an aggressive form, whether this object be to obtain possession of disputed boundary provinces, or to combine with other people of the same race who are for the time being under foreign domination, or to open outlets for trade and commerce, which a neighboring state closes. But these objects can only be attained by strategic attack; for if we merely sit still and wait, our adversary will certainly not bring them to us. Whoever once adopts the strategical offensive must follow it up with the tactical; because he cannot cry halt when the enemy is met, if he means to thrust home.

Exceptions are, of course, conceivable. The strategical attack may carry an army to points whose occupation may deprive the adversary of the essentials of life, so that the latter is forced to attack, and a temporary exchange of rôle takes place, a strategic offensive becoming a tactical defensive and the reverse. But such cases are rare.

A strategically defensive and tactically offensive state is even more difficult to conceive of; because no one is ever strategically defensive out of mere kindness, but always from a feeling of weakness, or on account of the unwieldiness of his army. But these are not the elements from which a tactical attack is liable to spring.

However, we are not concerned here with exceptions, but only with the rule, and that is that the strategical attack is naturally followed by the tactical, and strategical and tactical defense also go together.

The relative condition of the two armies also plays an important part. The side which is the first to mobilize and concentrate its forces will generally attempt to utilize this advantage for a rapid advance. When, on the contrary, a belligerent sees that he will complete his concentration later than the enemy, he will be compelled, for the time being at least, to take a defensive attitude, and cannot think of advancing.

Each of the belligerents will therefore find his rôle more or less determined by circumstances and he will be obliged to accept the situation. Hence, any discussion as to which mode of conducting war is the more advantageous seems all the more useless. It will be much more profitable for us to consider the characteristics of each of these two modes of warfare.

5. THE OFFENSIVE.*

a. *The Strategic Offensive.*

The strategic offensive, as we have seen, springs from state policy in its efforts to attain some particular object, and from a feeling of power to attain this object and consciousness of superiority over the adversary. The commander-in-chief will undoubtedly be inclined to utilize these advantageous circumstances, before there is time for the situation to be reversed.

Rapidity, activity and surpise are the life of the strategic offensive.

We already have learnt what should be its first objective, viz., the enemy's main army.

Irruption into the theater of war occupied by the enemy's army, in order to meet it and force it to battle under the most advantageous circumstances possible for us, is the program at the outset.

But, the belligerent who undertakes this work with a firm conviction of the advantages of the offensive, is much more inclined to keen intelligent action, to bold enterprises, to brave deeds, than he who calmly awaits events. Hence, the attacker will generally be the more active of the two.

Even in peace maneuvers we can see the effect of the offensive on the bearing of the leaders and the conduct of the troops.† Undoubtedly the mere adoption of the rôle of attacker confers a real advantage as regards the character of the operations, which should not be underestimated.‡

The attacker tries to find and defeat the enemy. A definite and decided purpose promotes insight, facilitates the adoption of correct rules of action and lessens the chances of making mistakes, because the actor, in this case, is sure of his object, and can only go wrong in the selection of the way to attain it.

The movement and action inherent in the strategic offensive facilitates the concentration of the advancing masses of troops.

---

* We retain this term of foreign derivation, now in common use, to which usage has given a wider meaning in this connection than is ordinarily assigned to it, since the *offensive* comprises not merely a single attack, but the entire series of operations up to and including the annihilation of the enemy's forces, while *defensive* signifies not only a single defensive act, but the manifestations of the power of resistance in general. In the French language the separation of the two ideas is simpler on account of the different expressions used: *offensive*, *défensive*, in the general sense, and *attaque* and *défense* in the restricted sense, for a single act.

† This explains why, in peace maneuvers, the decisions, unless they are those of an experienced and circumspect umpire, will almost always be in favor of the attacker.

‡ We often hear the assertion that psychological factors should not be considered in a work on the art of war, because spiritual forces and emotions can neither be measured nor estimated. They are, however, of such extraordinary importance that we would often give a very erroneous impression if we did not refer to them. A knowledge of human nature, is, it must be admitted, the most difficult but at the same time the most important part of the general subject of war, the mastery of which is essential to the commander-in-chief, in order that he may be equal to his high calling.

Each day's march to the front can be utilized to bring them closer together. This will be all the easier as the common object is known to all subordinate commanders. Their co-operation is simpler than in the case of the passive defensive, to whom the object is not known until the enemy appears before the position.

This favorable effect of the cooperation of the parts inherent in the attack, is the more important since the height of strategic wisdom is this, to be as strong as possible at the point where we strike the enemy.

Furthermore, the offensive has practically won the game as soon as it is successful at any one point; for, as a rule, the positions of the defender will constitute an organic whole, which will lose its strength and cohesion if any part is disturbed.

Moreover, the fact must also be taken into consideration that the attacker has it in his power to take the enemy by surprise, inasmuch as he selects the point of attack. Although this point can often be forecast with considerable certainty by the defender, by carefully weighing all the circumstances, still, he will hardly fail to make mistakes of detail. The attacker, therefore, has a right to hope that he will find the defender not fully prepared at the decisive point, and this will assuredly inspire confidence. Even should the length of time required by strategic operations on a large scale permit the defender to correct his mistakes, we must remember that great distances will also be involved and so the correction will probably not be complete. Errors in the original disposition of the forces can hardly be made good by the defender, for masses of troops cannot be moved about like chessmen.

Nor should the fact be overlooked that the attack takes the army continually into new regions. In a country trying to the troops change is in itself a great benefit. Change of locality tends to produce, on the side of the offensive, a moral and a material effect, very refreshing to the troops. This apparently insignificant circumstance may become a very important element in re-quickening an exhausted army. We need only consider the case of an army that has been lying for a long period before one of the enemy's fortifications, and is afterwards marched across country again in a field campaign, as was the case with the Germans when they were released from the siege of Metz.

Thus far we have had only advantages to enumerate for the offensive. But we must not forget that it makes great demands in the way of troops. Its nature requires the incessant employment of the troops, regardless of the numbers required, and the

constant movement incident to it, as well as the attacks with which it finally terminates, uses them up very fast.

In war losses on the march are even greater than losses in battle.

Since the attack should consist in a constant advance, if possible without intermission, till the object is attained, it leaves no time for rest and recuperation, or to call in the stragglers, or to assemble fresh troops. The Prussian Guard Corps, in spite of its splendid discipline, lost on the marches from the battle field of St. Privat to that of Sedan from five to six thousand men.*

The country through which the attacker passes must as a rule be regarded as hostile; it must therefore be secured against uprisings.† The advancing army is compelled to leave behind part of its forces, which cánnot take part in the subsequent actions.

The lines of communication of the army, moreover, over which all its necessaries of life are transported, require special protection.

At the same time the attacking army is increasing its distance from its base of supply. And, although this circumstance is now of much less importance in civilized countries than formerly, on account of the modern means of communication and transportation, such as railroads,. still it retains a value as a weakening element for the offensive that is not inconsiderable; for, we cannot count on railroads in the enemy's country, not even on such as we have ourselves repaired and put in operation, as we can on our own, and so we will not be able to bring up to the attacking army all the subdivisions in rear, whereas an army retreating concentrates naturally its forces as it moves.

The besieging of fortifications that cannot be left unobserved also costs troops.

Human nature is such that when everything goes well, and the necessity for great exertion is not so apparent as it is in a dangerous situation the tension of the troops will gradually relax.

Finally, an energetic and successful advance is apt to call forth the jealousy, enmity or apprehension of other powers, and these feelings give rise to political measures unfavorable to the attacker, thereby constituting another weakening factor, which

* Hohenlohe, *Letters on Strategy*, I, p. 55.

† Of course, we can conceive of a case where the attacker in an enemy's country, in which the inhabitants are of the same race as his troops, receives their sympathy and support; but such a state of affairs is exceptional and quite accidental, and is not the normal condition.

may even rise to armed intervention.* Moreover, under such circumstances the attacker is often in danger of losing his allies, who are willing to support him to a certain point, but do not intend to permit him to become dangerously strong.

A characteristic feature of the strategic attack is the fact that the portion of the army in contact with the enemy and which must fight the battles is only a very small fraction, often only one-fourth, or even one-eight, of the entire force in the field, while the fate of the whole still depends on the success or defeat of this fraction. Attacking forces melt away like newly fallen snow in spring.

Napoleon crossed the Niemen in 1812 with 442,000 men, but arrived in Moscow within three months with but 95,000. Thus the annihilation of a fifth of his fighting strength, during the retreat, became the decisive factor in the loss of the entire campaign and marks the turning point in his career. Even more striking is the example of the Spanish campaign of 1810. In the spring of the year 400,000 Frenchmen crossed the Pyrenees; they continued in uninterrupted advance and gained innumerable successes; nevertheless Marshal Massena brought but 45,000 men up to the lines of Torres Vedras at Lisbon where the decisive action was to take place. This force was too small to give the last decisive blow and thus attain the object which was almost within his grasp. A fatal retreat was the natural consequence, and marked the end of French successes in the Iberian peninsula.

Fieldmarshal Diebitsh had but 20,000 men left when he reached Adrianople out of the 160,000 which Russia had concentrated in the Balkan peninsula in the spring of 1829. Had he been compelled to continue his march to Constantinople he would have arrived there, according to Moltke, with at most 10,000 men. A cleverly concluded treaty of peace saved him from allowing his weakness to become known, and from turning back.

The state of affairs was quite similar in 1878, when the Russians brought to the gates of Constantinople but 100,000 of the immense army of 400,000 which they took over the Danube, and this number includes the sick, which are reported as at least half the entire strength. Even the Germans, in whose case the conditions were uncommonly favorable, brought to Paris but 171,000 of the 372,000 with which they crossed the border in 1870, and yet the defeat of this part of their forces would undoubtedly have given the entire campaign a different turn.

* Austria's conduct in the Crimean war and that of England in the last Turko-Russian war are examples of how effective the interference of third powers may become even without armed intervention.

We are right, then, in speaking of the diminishing strength of the attack as an undeniable fact, which must be taken into consideration, and which becomes more and more apparent the longer the line on which the attack advances. This circumstance shows the necessity for the proper organization and the proper strategic measures to enable us to continually strengthen the fighting point of the army by means of reserves, of which, as Clausewitz says, the roads behind the army should never be entirely empty. In the correct estimation of these relations is the fundamental principle for carrying out every offensive movement to be found. The boldest and best arranged strategical attack will end in destruction, if the available means do not suffice for the attainment of the ultimate object, the possession of which means peace. This is most distinctly seen in the fate of great commanders, from Hannibal to Charles XII and Napoleon I, who failed in this one respect and went to pieces on this point. They resemble bold speculators, whose means are not adequate to enable them to carry out their speculations, so that in consequence of a last, and often in itself quite an insignificant mishap, all their brilliant acquisitions are lost again at a stroke.

If we follow the course of the offensive we will find that unlike the defensive, it always has a culminating point where the original superiority is brought to such a state by the natural weakening which takes place, that although it may be sufficient for victory, it cannot hope for any further success. It is for the commander to clearly recognize the very moment this culminating point is reached, in order that he may lose no time in concluding a favorable peace, as Diebitsh did, or take up the defensive and protect what has been previously gained, until such time as the enemy may come to terms. In case the critical moment arrives too soon, *i. e.*, before the desired peace, the recoil will ensue, whose action will generally be more violent than that from a defeat on the defensive.

But the offensive not only demands a great number of men and a constant flow of reenforcements, but also requires special qualities in the army.

Since movement is the essence of the offensive it is evident that the subdivisions must be mobile, a circumstance which can be counted on only in well trained troops. Many independent actions and duties will be required of the separate parts, hence a considerable number of experienced and well-informed leaders must be on hand. The disturbing elements, which make themselves felt in the course of the attack, can be met only by troops

firmly bound together and under good discipline, who have become accustomed to work together during a sufficiently long term of peace service.

With young armies, that have received little instruction, a strategic offensive can only be successfully carried out when the enemy is of still poorer material. Militias are quite unfitted for it, and the mere advance will probably cause their forces to dissolve rapidly.

The strategic offensive, therefore, requires the possession of a powerful army, composed of good material, as an essential condition.

b. The Tactical Offensive.

In the tactical offensive, *character of the troops* and *number of troops* have different meanings from what they have in the strategical offensive. The importance of good qualities, however, is even greater in this case, since problems arise in the tactical offensive, such as the storming of intrenchments, defiles, bridges, fortified positions, etc., which cannot be solved at all with troops of medium or doubtful quality.

A single good battalion, which is not afraid of the enemy's fire, may suffice to storm a bridge defended by the enemy, while ten poor ones remain helpless before it, or one after the other make ten feeble attacks which lead to nothing. Scenes of this kind are furnished by the battle on the Lisaine. General von Werder's extended line of battle would probably have been pierced and broken by 40,000 energetic troops, whereas 120,000 troops of medium quality were not able to accomplish this.*

In general the tactical offensive, like the strategical offensive requires a superiority in numbers. Although this may not be absolutely necessary as regards the entire strength of the forces assembled on the battle field, this superiority is nevertheless required where the decisive blow is to be dealt.

In this case, as in the strategical offensive, the fact holds that the movement and action incident to the offensive facilitate the concentration of the forces on the point selected for the decisive blow.

* It is not intended to attach any blame to General von Werder's dispositions. Indeed, they conformed to the circumstances, although they did not follow the rules applicable in ordinary cases, inasmuch as an extent of front of nineteen miles for 43,000 men is excessive. General von Werder, however, was well acquainted with the character of his enemy, and knew that if he deprived him of the power of executing outflanking maneuvers he would not be able to derive any benefit from his superiority in numbers. As a relatively weak resistance all along the line was sufficient to hold the enemy in check, this arrangement was perfectly justifiable. Prince Frederick Charles proceeded in a similar manner against the French army of the Loire before the battle of Orleans. Both examples illustrate the fact that in the practical application of the principles of war we must take account of the character of our enemy.

Moreover, it increases the mental activity and spontaneous action of the leaders. It awakens their inventive faculty by presenting a variety of opportunities, and stirs up ambition and a desire to perform great deeds. It helps the men to overcome the feeling of danger and strengthens them through a sense of superiority; for every one knows that only from the conviction of superiority did the commander decide to take the offensive.

Even more clearly than the strategical does the tactical offensive make known the common objective. In the former it is surmised from the dispositions, but in the latter it is seen. This circumstance diminishes the danger of any portion of the forces going astray in the battle.

The effect of surprise is much greater in the tactical offensive than in the strategical, because the former allows the enemy less time to correct mistakes made from lack of foresight. The power to attack from several sides at the same time, to outflank one or both wings, to advance against a flank of the enemy and at the same time threaten his line of retreat,—all these advantages come into play here as well as in the strategical offensive.

Nor should we underestimate the value of the concentration of fire effect, brought about by the advance movement and the fact that the objective can be distinctly seen. The great ranges, especially of modern artillery, make it possible for troops, who do not actually belong to the attacking forces, and take no part in their advance, to assist by their fire in the decisive struggle.

Finally, the tactical offensive has the advantage of selecting the point where the decisive action is to take place, and in the tactical, even more than in the strategical offensive, is it true that victory is secured if a decided advantage can be gained at this one point. The fact that the defender's dispositions constitute a connected whole, which will have its stability destroyed if a portion is disturbed or gets out of place, is more decidedly true of the tactical than of the strategical measures of the defender. The defeat of a wing, the penetration of a flank may decide the fate of a battle. There have been instances, indeed, where the defender gave way when only one-fourth of his line was at a disadvantage, while the attacker, beaten back along three-fourths of his front, still triumphed, because he was victorious on the other fourth; this was the case on the 18th of August, 1870, at Gravelotte and St. Privat. The direct road to the breach in the enemy's line of battle is apparent to all the forces of the attacker, and the progress of events will itself bring

about concentration and cooperation. The moral effect of success will increase the natural force of the blow.

But the tactical offensive also has its inherent weakening elements. The forward movement alone constitutes the first in order. It deprives the attacker of a part of his strength through fatigue, before he reaches the enemy's line. This factor will be of very great effect, when, after a long march to reach the battle field, there remain considerable obstacles to be overcome on the field itself, as in the attack of the Prussian half-division Schwarzkoppen on the 16th of August, 1870. Many men sank from exhaustion and fell defenseless into the enemy's hands.

Another weakening element of the greatest moment lies in the fact that the fire is almost entirely suspended by the forward movement, and the attacker must therefore stand the fire of the enemy occasionally without being able to reply to it.

This, together with the circumstance that during the advance over the ground he is compelled to give up protection by cover to a great extent, causes the losses of the attacker, as a general rule, to be by far the greater. It is only after successes gained that he can retaliate, since the defender is then also forced to movement and will feel its disadvantages doubly since he will be in retreat.

There is another difficulty in the tactical attack in that its action is limited as to time. It must accomplish its task as a rule in one day. An indecisive battle often turns out at the close of the day to be a victory for the defender, a defeat for the attacker. Had the battle of Gravelotte-St. Privat been fought on a short winter's day, the French in all probability would have remained victorious. Night would have put a stop to the attack after the taking of St. Marie aux Chênes and Marshall Bazaine would have had time to properly reinforce his threatened right wing by the entire Guard Corps.

It is often regarded as an element of weakness in the attack that the attacker, constrained to act, is much more apt than the passive defender to make mistakes which the latter can take advantage of. But this disadvantage is counterbalanced by the fact that the attacker can take advantage of the imperfections in the original position of the defender, indeed, he bases his plan on them.

Moreover, one of the most difficult duties of the commander-in-chief is not only to recognize mistakes of the adversary at once, but also to take advantage of them; to do this implies

excellent dispositions in the first place and a proper subdivision of the forces.

There lies, in the high qualities demanded of the troops engaged in the attack, as already pointed out, what is not exactly an element of weakness, but is still an important difficulty to be met. They must be mobile and at the same time proof against the moral effects of danger. They must have a great number of well-trained leaders of all grades. All this requires a very long and thorough course of preparation in time of peace. With untrained armies the tactical attack, even with a superiority in numbers, is even more difficult to accomplish than the strategical.

All these factors must be carefully weighed before deciding on the offensive. If the majority are not favorable for us we can hardly be successful.

It must also be remembered that a successful attack demands, on the part of the leader, much greater severity towards his troops than the defense. The latter involves the least indispensable amount of military exertion, which self-preservation calls for. The attack, on the other hand, demands an excessive amount which only a strong character has the strength to require of his men. The act of deciding to attack increases the responsibility for the very great losses usually incurred; and from such a responsibility most men shrink.

6. THE DEFENSIVE.

a. *The Strategical Defensive.*

We must not conceive of the strategical defensive as such a state of passiveness that the army quietly waits in the position taken up until the enemy arrives and attacks it. Such a course of action can occur only in the rarest cases and can not in general meet with success. The strategical defensive should not exclude all movement, nor remain absolutely inactive.

This may be expressed by saying that the defender should take up a position which will permit of opposing the attacker, where ever he may appear, with a part of the army, and hold him until the subdivisions have been concentrated on that point and are ready to act in concert.

This form of the strategical defensive we meet in military history most commonly on the weaker sides. It has no special advantages, to be sure, but permits of postponing the decisive action, difficult to bring about in such a situation, and allows greater opportunity for fortunate accidents to intervene.

Another mode of action in the strategical defensive consists in the defender retiring before the attacker into the interior of his country, in order to let those factors, which naturally weaken the attack, act for a certain time before the decisive action is to take place. It often happens in such cases that the defender, who is continually approaching his sources of supply, is reinforced at the same time, and unites with forces which were not available at first, or which were not intended to be used in first line. It is self-evident that such a course can only be recommended when there is sufficient room to give the circumstances ruinous to the attack the necessary time. Moreover, the portions of country given up in the retreat should naturally not be so important that their loss may in itself play a decisive part.

The third method of bringing into play the element of movement in the defensive, consists in quietly awaiting only the preliminary movements of the attacker, in order to detect any errors or weaknesses, and then, taking advantage of them, falling upon him with the forces collected in the meantime.* This mode of conducting the defensive is often considered as, in general, the most effective, the ideal method. But, as has already been said, the fact is overlooked that in this case the defensive gives up its own proper character and is not actually defensive in principle at all, but subordinates itself to the offensive and becomes merely an auxiliary to the latter. It is rather an attack, which is waiting for the propitious moment to arrive, than a defense, and we have no real right to classify an operation of this kind as defensive.

In the strategical defensive the fundamental idea is to equalize relations originally unfavorable to us, by an economical use of our own forces, while the adversary uses his up more rapidly in attacks.

The effort to attain this object is favored by the fact that in the defensive, the element of movement, which, as we have explained, is in itself a disturbing cause, plays a much less important part than in the offensive. With comparatively poor troops we can therefore much better risk taking the strategical defensive than advancing to a strategical attack.

But there are other strengthening or facilitating influences.

In the first place, we must take into account the circumstance that the defensive strives directly towards negative objects only, and these are much more easily attained than positive ones.

* Blume (*Strategie*, 1st edition, p. 109) designates these three modes of carrying out the defensive, as *position*, *retreat* and *attack* defensive, respectively.

The latter require action, and that is more liable to bring about unfavorable accidents than is the awaiting of events. If the attacker makes mistakes in his dispositions and his undertaking is thereby frustrated, the defender can claim a victory without really having done very much. The adversary has hastened the destruction of his own forces, and that is the principal object of the defensive. Clausewitz says of the defender: "he reaps what he has not sown".

Even the intermissions and any unnecessary loss of time in the movements of the attacker will act in favor of the defender. He may even have the advantage, under certain circumstances, due to the fact that by a certain time he is not yet definitely defeated. This may happen when, for example, a turn in the affairs, due to the intervention of powerful allies is to be expected, as in the case of Turkey at the beginning of the Crimean war. Time is, as a rule, the defender's friend, since the attack, even if it be not in itself too weak, often grows lame from the fact that the final issue is too long delayed.* The defender is interested in holding, the attacker in acquiring, and the former is generally in a military sense the easier.

The strategical defender is not compelled, like the attacker, to tear himself away from the theater of war with which he is familiar, and which he has himself selected and probably prepared with special care, and advance into an unknown country. He is better secured than the attacker against disasters, which may be caused by the unexpected appearance of obstacles. Since we must assume that the defender possesses a more thorough knowledge of the region in which the war is carried on than the attacker, and that he is already in position there, while the latter is only just arriving, the operations of the former will be much less subject to friction than those of the latter. The railroads of the seat of war can be much more useful to the defender than to the attacker, who usually has control only of lines occupied by force, which have been deprived of their proper personnel and in great part destroyed, and are generally in disorder. Finally, the defender can make use of the natural and artificial defenses, which a country offers, such as streams, lines of heights, woods, marshes or deserts, which the enemy must gain possession

* Only when the material means available in the two countries differ abnormally in quantity, as in the American war of the secession, is the reverse true. To be able to hold out long enough in war is one of the essential conditions of a successful strategical defensive. The latter can rely with great confidence on the fact that this is in reality an element of strength.

of in order to cross, as well as forts and fortifications, which delay him or compel him to divide his forces.

Let us, however, consider further the consequences of the defender being in his own country, the attacker in a foreign one. Under such circumstances the former can call on the inhabitants for assistance, which, particularly in the matter of obtaining information and the subsistence of the troops, will be of considerable importance. He has also, as a general rule, control over the ordinary administrative branch of the government in the seat of war, which can be of great service in the supply and quartering of the army, in the reparation of losses and the transportation of large bodies of troops.

In a wider sense the defender will have the support of the entire population, whereas the attacker leaves this source of assistance behind. This does not refer to an armed uprising of the people, but merely to that assistance which a patriotic people can give in the defense of a country, while rendering the movement, shelter and subsistence of the enemy in the land more difficult.* On the part of the defense as the danger to the fatherland and to hearth and home becomes more and more evident, the inhabitants are spurred to greater effort, and passions are aroused which may increase the power of resistance to a degree previously unsuspected, as was the case in Spain in 1808–1812, and in Germany in 1813; and also (after the fall of Sedan) in France in 1870. The attacker, whom his own people imagine on the road to victory in the enemy's country, without appreciating the difficulties and dangers with which he is battling, has not these forces at his command in anything like the same degree. It will often be difficult to fully grasp the almost imperceptible, but to the practiced eye still recognizable indications of a threatening turn in affairs, so that it may happen that the support so highly necessary for the successful termination of the campaign fails the attacker just as the goal is almost reached, as it happened to Hannibal in Italy.

The greater freedom of action thus vouchsafed to the defender also give him the opportunity to prepare surprises for the adversary. He has the power, since he can live in any part of the

* It is assumed that the public spirit in the country of the defender is alive and active, taking part in all the affairs of state and prepared to make sacrifices, and also that the people are accustomed to work for the army. If this is not the case it may happen that just the reverse obtains, and the enemy's army, which has no regard for the people's feelings, fares better than the defenders in their own land and among their own people. In the campaign of 1806 the Prussian and Saxon troops almost died of starvation in a rich country, because they did not dare to seize its stores of provisions, while the enemy used them without stint. In the winter campaign of 1870-71 it so happened that the French during bitter cold weather bivouacked in the streets of their large cities, because it was not considered proper to quarter them in the houses of rich citizens, while the Germans who followed made themselves comfortable on these hearths and at these same tables.

country he chooses, to change suddenly the direction in which he first opposed the adversary, and to take up positions to one side. By this means the attacker is also unexpectedly forced to give up the direction in which he has thus far been moving, and along which he has made his preparations for the support of his army. This is in itself a considerable difficulty. Since the region is unknown to him, but on the contrary is well known to the defender, this sudden change may cause, in addition, errors and disasters which increase the evil.

The attacker, as he will have more difficulty, on account of his rapid advance, in providing for the sustenance of his troops than the defender, will probably have to divide his forces oftener, in order to advance on a broader front and so draw more supplies from the country. This will furnish the defender the opportunity to fall on one of the parts with his united forces, before the others can come up in support. If he succeeds, there is the further possibility of operating successfully with these same troops, fresh from a victory gained over one of the enemy's columns, against a second or even a third with the same result, Napoleon in his attack on the Silesian army in the days from the tenth to the fourteenth of February, 1814, gave us a brilliant example of this. On a larger scale Frederick conducted his defense in the seven year's war in the same way.

As long as the army of the defender is not beaten decisively it exerts a perfectly natural attractive power on the attacker, just as the magnet does on iron. The attacker seeks it for the purpose of defeating it, in order to free himself from the influence which its proximity has on all his undertakings. Hence, we can assume, in general, that the attacker will proceed to the point where the defender takes up his position. This fact alleviates the difficulties of his situation considerably.

Should the attacker attempt to pass by one of the positions of the defender, which commands the theater of war, the latter will in general merely have to stir to make the attractive power of his army felt. Even the slight demonstrations of the Turkish army of the Danube against the left flank of the Russian army in the summer of 1877, and the advance of Osman Pasha on its right flank, sufficed to recall that army from its overhasty early enterprises beyond the Balkans. The attempt of the attacker to pass the defender without concerning himself about him, can always be met effectually by an attack in flank, as Schornhorst advised the Prussian army to do in 1806, although the attempt proved vain, and as he advised the allies in May,

1813, at Lützen, where it proved successful, and as General von Werder on the 9th of January, 1871, succeeded in doing to General Bourbaki at Villersexel.

The strategical defender can make use of his greater freedom of action without fear, especially in his own country.

One of the most important conditions for the strategical offensive we have stated to be the completion of the concentration of the forces earlier than the enemy. The fulfillment of this condition depends on the laws governing the army, as well as on the system of mobilization, on the possession of ample stores and abundant means of transportation, and finally on the geographical form and character of the country. It also requires a considerable supply of money. It is difficult to have all these conditions combined. The desire to equal in these matters neighboring states more happily situated, may almost ruin a country even in time of peace.

He who limits himself to the strategic defensive is, therefore, free from all this. He can generally, without detriment to himself, give the adversary a short start, provided it is not so great that the lines or positions of defense, intended to be made use of, are reached by the enemy before they are occupied by his own troops.

In discussing the offensive we stated that the defender has as a rule a better prospect of support from other powers than the attacker. Recently, a balance of power has been established in Europe, in the preservation of which all the powers have an interest. They will, consequently, be averse to a disturbance of this balance by the annihilation of any one of these powers, will oppose it and will fall upon a victorious power that attempts to go too far. If the intervention of the powers, not directly taking part in the war, in favor of defeated Austria in 1866 made itself felt in but a very weak diplomatic action of Napoleon III., and in 1871 had no effect at all on defeated France, it was because of the wise limit which the conqueror himself set to the use he proposed to make of the superiority gained.

The general tendency springing from the great age of all European states, to preserve the existing state of affairs, and which is predominant to-day, naturally works to the advantage of the strategical defensive, whose essential principle is preservation. In the seven years war young Prussia experienced the danger of disturbing such a state of affairs. Only the extraordinary genius of a great sovereign saved it at that time from destruction.

Opposed to the advantages which pertain to the strategical defensive there are, however, some important disadvantages. A general feeling of weakness is almost inseparable from this form of conducting operations. Indeed, it was from this very feeling that the determination to limit ourselves to the defensive sprang.

And now we will once more call attention to the fact that with mere defense nothing can be accomplished. The very utmost that can be expected of the strategical defensive is a peace granted by the opponent as the result of sheer exhaustion. Such a peace Frederick the Great succeeded in winning, but even then a change in the political situation came to his assistance. The mode of warfare of his day also favored him to an extraordinary degree.

The attempt of the southern states in the American war of Secession to tire out their superior adversary failed, in spite of the utmost patriotic devotion, and in spite of better armies and abler leaders. In the Turko-Russian war the strategical defensive, though successful at first, finally succumbed. If an army is not able in the end to pass from the defensive to the offensive it may in general be considered lost. Its defeat is merely a question of time.

The strategical defense must in most cases give up in the very beginning portions of its country, involving the loss of certain sources of supply; because it will hardly ever be possible to conduct the defense exactly on the border. Only when the defender succeeds, after a victorious campaign, in again taking what was at first abandoned to the adversary, does he escape without loss. The difficulty of coming out without loss is therefore increased by the very adoption of the strategical defense.

The moral effects, resulting from the feeling of weakness inherent in the defensive, and its forced inaction in waiting to see what the enemy is going to do, weigh heavily against it. While the activity on the part of the attacker develops new intellectual and moral forces, the standing still in uncertainty on the part of the strategical defensive puts those taking part to a severe test. We have already stated that the defender can arrange surprises for the attacker by observing his movements and falling upon him as soon as he detects an error; but this is not at all easy, for the situation is never quite clear. The attacker will probably strike the defender not merely in a single point, but in several at the same time. As a rule at each separate point struck the troops will assume that there is the principal danger. "Usually, under such circumstances cries of distress and danger

are heard on every side," says Clausewitz. The uncertainty involved leads to false alarms and to exertions, which, when they are found by the troops to have been unnecessary, are doubly effective in depressing their spirits. Only a very keen and experienced eye can at once detect the proper point to turn to. Moreover, advantage of the attacker's mistakes can be taken successfully only by prompt action, and this requires great tactical superiority. Hence, even in this respect the advantages of the strategical defense are conditional and limited.

Furthermore, the latter can never be entirely free from the danger that the adversary advancing to the attack, may threaten its lines of communications to the rear, even if there be a number of these. The defender will, indeed, often have to give up advantageous positions merely to protect his lines to the rear.

Finally, it is to be noted that the strategical defensive deprives the troops for long periods at a time, of the benefits of change of locality, a fact which increases the danger of ravaging diseases, and produces as a rule a depressing effect on the spirits of the soldiers.

But none of these disadvantages are to be compared with the one fundamental fault, viz.,—that with the strategical defensive —and the defensive in general—we can only avoid defeat, but cannot gain victory.

b. The Tactical Defensive.

Most of the characteristics and conditions which affect the strategical defense also come into play in the tactical. A few of them act in a different way.

The principal advantage of the tactical defensive lies in the fact that it avoids the danger of permitting troops to be shattered in a vain assault against the enemy's positions. On this account if the commander-in-chief is free to act, it is generally chosen. Stubborn attackers are readily tempted, especially in battles around towns and villages, to expend great energy on an object, the attainment of which will not counterbalance the losses. An attack may result in a waste of troops. Even victory, in view of the destructive action of the fire-arms of our times, will often be bought so dearly that the general situation, instead of being improved, will be made worse. Pyrrhic victories are the usual fate of the tactical offensive of our time. The desire to fully utilize the effect of fire tempts in general to the selection of the defensive, especially after sad experiences of losses in offensive battles. Indeed, the defender has continued fire action, whereas

the attacker is compelled to interrupt his fire by intervals of movement. This advantage is lessened only by the eccentric action characteristic of the defense, whereas that of the attack is naturally concentric. Hence, the assistance afforded by the terrain is even more effective in the tactical defensive than in the strategical. The defender tries to have obstacles in the way for the adversary to advance over under fire, and these he can often strengthen artificially. Moreover, the defender enjoys the special advantage of being able to post his troops under cover and to keep his dispositions secret, whereas the attacker is compelled to advance in full view, and generally even on the open roads.

This would vouchsafe to the defender, more opportunites for surprises than history tells us of, were it not very difficult to get troops out of positions they have once taken up quickly enough to take advantage of the observed mistakes of the adversary. The picture of a defender in position, and at the same time lying in wait to detect a blunder of the enemy, and ready to pounce upon him, is all very well, but is seldom realized.

An army cannot, like a tiger, pounce upon its prey with the rapidity of thought. The survey of the ground requires time to discover the opportunity, the judgment requires time to mature, the order requires time to reach the troops, and the latter require time to organize the attack and get under way. This gives a sum total of time that generally permits the rapidly advancing attacker to tide over the critical moment.

The difficulty of moving troops, which have once taken up a position, in a direction other than to the front explains the weakness of the flanks of a position. Otherwise, the defender, who has the shortest distance to go, would always complete his change of front before the attacker has completed his flanking movement.

To be attacked from several directions at the same time, perhaps occupied in front while outflanked on one or both flanks, or even deprived of one's line of retreat,—this is the chief danger to which the tactical defense is exposed; and it is more difficult to reply with counter-attacks in this than in the strategical defensive, because the space is too limited, the time too short, to enable us to organize and develop them fully. Even an advance with the same troops, first against one part of the enemy's army, then against another, in other words operating tactically on interior lines, will hardly ever be possible, because the distances between the separate groups of the adversary's

army are too small, and therefore we will find ourselve not only between two adversaries, but also between two fires.

Tactical counter-attacks on the battle field, other than the ordinary kind that consists in a direct advance to the front after the attack has been repelled, require a mastery of the art of handling troops like that which Napoleon possessed. At Austerlitz he gave us a model example, but such examples are rare.

It is more likely that the very moment the decisive blow is to fall and after the attacker has made all his arrangements to move in one direction, the defender will prepare surprises for the attacker by unexpectedly appearing in another. The attack, under these circumstances, must often be combined with a change of front, and this is the most fruitful source of confusion and misunderstanding.

Although the fact that the troops on the defensive are stationary constitutes to a certain degree an element of weakness, on the other hand it has the advantage of not requiring of them such activity or steadiness, nor such experienced leaders, as does the offensive. With troops which, on account of their character, would not be capable of carrying out an attack in the least degree energetic, we can still carry on a very fair, or perhaps even a successful defense. There is a great difference between the two modes of action, and, if one has the choice, with comparatively poor troops the defensive often offers the only safe refuge.

7. ALTERNATION OF OFFENSIVE AND DEFENSIVE.

It is very difficult to give definite rules for the alternation of the offensive and the defensive. The nature of these two methods must be carefully taken into consideration, and that selected which is for the time being, the more advantageous for our army and the more useful for attaining the object sought. The determination of the proper moment for passing from one to the other is a matter of tact. The commander-in-chief must feel the pulse of the army in order to know what may be expected of it.

In the domain of strategy it is proper to pass from the offensive to the defensive as soon as the destructive effects, which the former, as we have seen (p 49), exerts on the army from perfectly natural causes, have become so great that our superiority over the adversary, which originally induced us to adopt the offensive, is in danger of being lost. It would be wrong in our desire to utilize that original superiority, to continue the advance so long that recourse to the defensive might be imposed upon us by the force of circumstances. This would be the more ruinous, since

with such a compulsory change are connected losses in morale and in physical power, which will not permit the attacker to remain long at the highest point reached, but will soon force him down to a lower level.

The commander-in-chief must himself select the time for passing to the defensive, and must have the strength of character to give up the offensive voluntarily, if he wishes to hold what he has gained. But in weighing the situation he must be careful that the losses which he sees in his own army do not involuntarily make a greater impression on him than those which his fancy ascribes to the enemy. Otherwise he will be apt to stop the attack too soon and hence will not reap the full benefit of his own advantages. To wait until the very latest moment and then pass to the defensive of one's own free will, is the most difficult feat in the art of war.

In tactics the same ruling principles obtain. An attack carried too far will usually result in a disastrous retreat, because in the field of tactics events succeed one another with greater rapidity than in the domain of strategy, and when once the army begins to recoil it will be doubly difficult to stop it. Here the impress of the moment has a more powerful effect. Nevertheless it is easier in the domain of tactics than in that of strategy to hit the right moment for passing to the defensive. The loss of strength and energy is more distinctly visible. The commander-in-chief not only has the army under his eyes but can overlook the entire theatre in which the drama is being enacted. The limit to which the attack can and should be pushed, in order to be able to take up the defense of what we have gained, can be more readily seen. In general terms this limit is the enemy's line of defense; more specifically it is the strong points in this line, such as villages, walled farm yards, woods or lines of heights. The rules of tactics teach us, in fact, not to advance beyond such places immediately after taking them, but first to occupy them strongly, to reorganize there, to secure the position,—in other words to pass occasionally to the defensive.

The passage to the offensive should not be forced upon the commander in tactics any more than in strategy, but should be the result of insight and deliberate determination on his part.

To pass to the defensive because the distances passed over and the consequent fatigue of the troops are too great, points to imperfections in the preparatory measures. But accurate estimation of these elements beforehand is very difficult, and requires

a strong command over. one's imagination, which readily adapts itself to our secret wishes and consequently gives rise to illusions. Napoleon I, has been blamed because in 1812 he did not stop after the battle of Smolensk and pass to the defensive, as his preparations for the supply of his army, great as they were, showed themselves insufficient for any further advance. If this great genius can make a mistake of this kind, how much more easily will other men do it.

Passing to, the defensive merely to take advantage of the ground and make use of a strategically or tactically strong position will rarely accomplish the purpose of the attack. The reasons, which up to this time induced one to attack and the other to limit himself to the defensive, continue even after the time arrives when he would like to see an exchange of rôle. We cannot expect the defender, who but a moment ago considered himself too weak to stand up against us, all of a sudden to do as we wish and pass to the offensive; and this, too, when he has a strong and advantageous position in his front.

Bloody attacks, brought about by the strategical offensive, may make a change of rôle necessary. The defensive gives time for bringing up reinforcements, and furnishes opportunity for making the enemy suffer greater losses for a time, by forcing him to fight offensive battles from time to time, so that the total expenditure of force is equalized, and the original proportions obtain once more. This would be the case, for example, should we succeed in surrounding and hemming in the enemy's army, so that it is compelled to fight its way out at any cost, or should we cut a line of communication without which it cannot exist. But such favorable conditions are rare. Theoretically we must take them into consideration, practically we cannot in general count upon them.

The alternation of offensive and defensive may also consist in making use of both forms at the same time. The parts of the army which are not intended for the decisive blow are left comparatively weak and are cautioned to merely occupy the enemy, to retire before him whenever he advances with superior forces, and to advance again the moment he weakens his lines;—while those designed to strike the decisive blow are made so much the stronger. The allies made use of this combination of the offensive and defensive very successfully in the fall campaign of 1813, when they decided to retire wherever Napoleon appeared with his main army until he gave up the pursuit, but to strike with all their might wherever his marshals, commanding independent

subdivisions, opposed them. The one violation of this rule of action by the Bohemian army, on the 26th and 27th of August, cost them the battle of Dresden. On the other hand, by following the rule, the army of the North and that of Silesia gained the battles of Gross-Beeren and Dennewitz and that of the Katzbach, respectively. However, such a mode of procedure requires an experienced eye and prompt action. In this art Blücher was a master. He succeeded twice in drawing the Emperor after him into Silesia, without giving him the opportunity so keenly desired of bringing on a battle. In both instances the latter had to give up the pursuit, because the advance of the main army from Bohemia against Dresden recalled him. He gained nothing in the end and merely used up the strength of his forces to no purpose.

The difficulty of seizing the right moment for passing from the defensive to the offensive lies in the fact that this moment must generally be determined from the state of the enemy's army, and there are only uncertain indications from which one can draw conclusions. The situation will very rarely be so simple that a great accession of strength on our side, and a distinctly apparent falling off on the side of the enemy, will make obvious the time for passing to the offensive.

The business of the defense is to hold, that of the attack to acquire,—and this by expending forces. Like a good business man the commander-in-chief should not waste his means where the result does not pay, nor should he be parsimonious where tempting gain is in prospect. In the happy combination of these principles lies the proper distribution of the forces in time and space, and consequently the victory. To be equally strong at all points and to make the same effort everywhere is a sure sign of helplessness. Only he who knows how to economize his forces at points where a disaster can have no decisive effect, will be in a position to attack with energy at another point, and thus obtain a superiority at a single point,—always the one thing to be desired.

Translated by Lieutenant JOHN P. WISSER,
1st Artillery.*

* The portion translated above is about one-third of the entire work. The translator is greatly indebted to the assistant editor, Lieutenant G. Blakely, 2nd Artillery, who made many valuable suggestions and discussed with him the wording of many difficult phrases.

GARRISON ARTILLERY WARFARE.

Reprinted from *Proceedings Royal Artillery Institution*, May, 1896.

When deciding on the plan of defense of a coast fortress, it is essential in the first place to consider the nature of the attack to which it is liable to be exposed. This in its turn will depend to a great extent—

1. On the armament and resources of the fortress.
2. On the strength, composition and *morale* of the garrison.
3. On the relative value of the fortress to the attackers and defenders.
4. On the necessity for its destruction or capture for strategic reasons.
5. On the necessity for the destruction or capture of any material or ships which it protects.

In all these conditions, the question whether "the game is worth the candle" will present itself to the assailants. A modern battleship, cruiser, torpedo-catcher or torpedo-boat is valuable only so long as she is afloat and in a more or less undamaged condition. They take a long time to build and repair, and once badly damaged, are not likely to take any further effective part in the hostilities, since all authorities are agreed that the next war will be short, sharp and decisive.

They represent not only a large capital sum of money, which no nation can afford to recklessly lose, but, what is more important, the command of the sea to that combatant who can last bring an effective fleet into action.

The primary object of an armed ship is to fight ships, and the naval strength of a nation should not be wasted in attacking a coast fortress without some very good object in view, which will justify the expenditure of a fleet, if necessary. These considerations will therefore doubtless influence the admiral of a fleet and prevent him from rashly undertaking adventures to capture another Gibraltar, simply because he has nothing better to which to turn his hand. Roving attacks of a piratical character to harass, destroy or hold to ransom weakly defended or undefensible sea-ports may be expected, when once one of the powers has asserted its local supremacy on the sea; but at the commencement of hostilities these excursions must give place to the more important operation of clearing the sea of the opposing

ships of war. Consequently we may imagine that an attack on a coast fortress will be an affair of some importance, and every available warship will be collected for the purpose.

When the object of the attack is the capture of the fortress, we may assume that a land force will undertake the operation, assisted by the fire of the fleet. The attack of the fleet will then only be of secondary importance, its duties being the destruction of the batteries bearing on the land attack and the engaging of as many other batteries as will compel the defender to employ a large part of his force in replying to the fire of the fleet, thus weakening the main defense.

It will hardly be possible for a fleet to so silence all the fire of a well garrisoned fortress, as to be able to land sufficient men to capture it against the wishes of that portion of the garrison (*i. e.* the infantry) who have hitherto been merely spectators, unless the strength of the fleet is overwhelming in comparison to that of the fortress. There would also be the risk of dangerously undermanning the fleet, should sufficient men be detached to hold the fortress when captured; a serious consideration if the fleet has to return probably some considerable distance to replenish its stock of ammunition, which will be much depleted, if the defense has been at all vigorous and tenacious.

In a word a coast fortress *per se* would never be attacked by a hostile fleet, there would be nothing gained by doing so.

But coast fortresses are built for some well defined purpose, either to protect a fleet while repairing or refitting, or to afford it a refuge from a hostile fleet, or to protect stores of coal, etc., which are essential to the efficiency of a fleet.

A coast fortress therefore may expect attack when there is a fleet under the protection of its guns, or it may be attacked by a fleet having local supremacy, even when no ships of war are in the defended area, either to possess itself of the stores, etc., protected by the fortress, or to destroy them and thus impair the efficiency of the opposing fleet.

If the object of the attack then be the destruction or capture of *matériel* or ships defended by the guns of the fortress, it will be sufficient for the purpose of the attack, if the fire of the defense is either silenced, kept under or avoided sufficiently, to enable that purpose to be carried out and the fleet withdrawn.

The *raison d'être* of the fortress and arrangement of the defenses will serve then as a guide to anticipating the nature of the attack to which it will be exposed on the sea side; while the general dispositions of the fleet will depend on the amount of sea

room at the disposal of the attackers and the conception of the admiral in command, of the manner in which the defenses are able to interfere with his own plan of operations. The attack of the fleet on a sea fortress, therefore, may assume two phases:—

The secondary attack—The artillery duel.

The primary attack—Torpedo or boat attacks.

As regards the secondary attack—this attack will be made either at "long range," from 5,000 to 3,000 yards; at "medium range," from 3,000 to 1,500 yards; at "close range" within 1,500 yards, or the ships will "run past" the defenders' fire when the real object of the attack is situated in rear of the defense and out of reach of the attack and until the fire of the defenders is evaded.

The attack at "long range" would, as a rule, be for the purpose of dividing the attention of the defenders from the main attack proceeding elsewhere, or would be used for a bombardment pure and simple.

In these cases the attackers will endeavor to do the greatest possible damage to the defenses, with the least possible chance of injury to themselves. The attack will not be pushed home unless it becomes apparent that the object will not be gained without it, or the feebleness of the defense invites the attackers to do so, and convert their secondary attack into a real one.

"Medium range" would be used when greater accuracy is required, while the position of "close range" would be taken up to enable the machine and quick-firing guns to keep down the infantry, quick-firing and machine-gun fire which would be used to repel a landing or attack by torpedo-boats.

A fortress, or a portion of it may possibly lend itself to a simultaneous attack at all these various ranges, combined with the phase of "running past;" but the probability of such a variety of attacks will depend entirely on local features. It will be evident therefore that the attackers must conform to more or less fixed rules, and that the nature of their operations and tactical dispositions will depend on the object they have in view and its importance. The strength and composition of the fleet, and the manner in which the attack is conducted will disclose their object, even if the defenders have not previously received information of the departure of a fleet with some specific purpose, from the enemy's shore.

The tactical formations of the attackers will further be influenced by:—

(*a*) The nature of their armament and thickness of armor, and

the natures of the guns of the fortress with their distribution, positions, and arcs of fire, in conjunction with the 3 and 5 fathom lines and mine-fields. Generally speaking as we know all about the armament of ships as fast as they can be identified, so it may be imagined that the attackers know the numbers and natures of the guns opposed to them, their distribution and arcs of fire. The effect of the other consideration is obvious. A naval officer once remarked to me when I was talking to him on this subject, "we should run in close and pour in a heavy fire from everything we have got to fire with. It will be all over in 15 minutes." "One way or the other," I suggested, and I cannot but think that his plan would not be universally successful in capturing a fortress.

(*b*) *The time at their disposal.*—This consideration will only come into force when the attack is of the nature of a raid on the *matériel* or ships protected by the fortress, which must be more daring than when the object is the capture of the fortress itself; for this last must necessarily be a long operation, and would not be undertaken till the fleet held the command of the sea, and in that case their time would not be limited.

(*c*) *The character of the defense anticipated.*—If the defense is likely to be weak, it would be the best policy to crush it at once; but if vigorous, then the energies of the garrison must be first worn out by harassing them from "long range," combined with frequent "close" attacks.

(*d*) *The state of the weather and direction of the wind.*—These are important factors. A rough or choppy sea is all in favor of the defense, since their guns are on steady platforms. The false atmosphere created by the smoke of the guns, and the manner on which it is acted by the wind, whether it hangs about the ships or batteries, may be turned to the advantage of one side or the other. At any moment a change or lull in the wind might alter the whole situation.

The main issue, however, is the vulnerability of the fortress itself. Neglecting the strength of the garrison, and the possibility of destroying the food and water supply by the fire of the fleet; we may say that given the necessary armament, the vulnerability of a fortress, from an artillery point of view, depends on the invisibility and consequent protection from fire of its batteries, range-finding arrangements, command posts, and communications.

It is obvious that a target lends itself to be aimed at and struck; consequently a fortress whose works offer no target is in

a much better position for defense than one whose works do so, and its vulnerability is decreased thereby. Its vulnerability will further depend on the disposition of its works and the armament mounted therein; whether they give each other mutual support or are so far apart as to invite attack in detail from want of it. But guns should not be dotted singly here and there with emplacements "freckling" the face of the fortress in pursuit of invisibility; rather should they be placed in groups of the same caliber, and in as many groups as may be considered advisable, with due regard to invisibility of position. The effect of dotting guns singly here and there may be well illustrated by the fact that one groom can very well look after two or three horses in one stable; but if they are in different stables he cannot possibly look after them so well, and there will always be a delay in finding him when required to bring out a particular horse without previous orders. The introduction of guns of different caliber into a work, means special corrections in ranging each nature, and so should be avoided if possible.

As regards the armament.—The position of the gun should be such that its projectiles can most easily penetrate, and its fire generally be most injurious to the objective against which it is intended to act. As previously noted, the modern warship is built to encounter ships whose guns have no great command, consequently all their heavy armor is at the sides and round the primary armament, and is capable of resisting the direct impact of projectiles, except those having great momentum. We must therefore make our warfare in a way to which these ships are unaccustomed, or we lose the great advantage which the choice of sites for our batteries confers on us.

No ship afloat can resist a plunging fire on the unarmored decks, while the armored deck is liable to penetration by high angle fire and plunging fire from guns using heavy projectiles. We may take it as an axiom therefore that the greater the command the more effective the results of the fire, *i.e.*, that a comparatively light gun on a high site firing on to a deck, will do much more damage to a ship than a moderately heavy gun on a low site firing at the side of the same ship. The maxim "the flatter the trajectory the lower the site," seems to me to play our opponent's game, except where a nearly point-blank range commands the approach, and the penetration at that range is greatly in favor of the projectile. For instance, a gun with a flat trajectory and great penetration is not wasted where it is intended to combine the functions of a shot gun and rifle, *e.g.*,

to protect a mine-field or repel a torpedo raid, and at the same time to try conclusions with an ironclad. Unquestionably, if it has only to act as a rifle, the sooner it is transferred to as high a site as possible the better. Similarly with Q. F. guns, if the channel which they command is so narrow that torpedo-boats must pass within point-blank range, the lower the site the better as the guns thus get the full advantage of their flat trajectory, and they are powerful enough to penetrate if their shell strikes the sides, but if the channel admits of the passage of an ironclad, their low site prevents their effective use against the superstructure on which alone they can make any impression; consequently an ideally protected passage would be provided in addition to the Q.F.'s on the low site with a battery of Q.F. guns with a high command. Just as in a battle between two armies, the fire of the artillery forces the opponents to deploy into fighting formation and commence the engagement at the furthest possible range; so should the high angle fire of the fortress force the opposing fleet to disclose their plan of operations at the earliest possible moment, and so give time to the defenders to make arrangements to meet it. The possibilities of hits at 10,000 yards are well within the powers of the directing P. F.* But should the fleet approach in cruising formation, it might perhaps be better policy to wait until the ships are closer in, so as to increase the probability of one or more being temporarily disabled while assuming their fighting formation and so causing a slight check, of which advantage would be taken by the defense to pour in a heavy fire.

Let us now turn to the range-finding arrangements. Considering the P.F. first: When a gun can be laid over the sights, the general rule is for the P.F. to be used as a range-finder only, the direction being given by the gun layer; but when this is not practicable from any cause, the gun is laid and fired by "P. F. predicting." But owing to smoke from adjacent guns and other contingencies, it is obvious that a gun cannot always be laid over the sights, and this will inevitably be the case in the final stages of an attack pushed home, when every gun will be fired as rapidly as possible, at the most visible assailant, except those which are directed by a P. F. and where the P. F. operator can see over or through the smoke, when they would be fired by "P. F. predicting." In the chaos of such attack, the number of guns that can still be directed and fired in this way will have an

* Position finder.

enormous influence in deciding the fortunes of the day, as by so doing, the loss of *personnel* at this stage will be appreciably diminished. At this period everything will depend on the nerve and coolness of the operator in his cell. He should be shielded therefore from any disturbing influence, and every resource of skill and cunning should be utilized in locating the P. F. The first consideration being where it can best exert its influence for the longest possible period during the fight, and the next how it can be best concealed from the enemy's view; to build a little house for it on the flank of a battery, thereby making a conspicuous target of it, when near at hand there is a top story room in a house of advantageous frontage that could be hired or bought for the purpose, is against common sense. If the little house exists, it should be left as a decoy, but I should certainly recommend the removal of the instrument to the top room aforesaid. In some cases, it must be in the work itself, if it is to be used at all. There it is naturally out of place, and in its lowest sphere of usefulness, but if there is absolutely no other position for it, then it must be concealed by every structural expedient.

Let us now take the case of the D. R. F., the elder brother of the P.F. Owing to the method in which it is worked, it must be situated in or close to the work whose guns it ranges. It must have a clear view of the water area these guns command, consequently the instrument and operators are exposed to fire, the amount of the exposure depending on the visibility of the work and instrument. If the position of the D. R. F. can be ascertained by the attackers, it is obviously to their advantage to render it unworkable as soon as possible. If they see a cluster of heads or an unusual projection on the skyline of the work, it will be quite worth their while to devote the fire of a portion of their Q. F. guns and Maxims to it. Thus we see that to obtain the greatest effect out of either of these instruments, it is absolutely necessary that they and their operators should be well concealed from the enemy's view, which at present is unattainable by the D.R.F., and consequently it would fail in its purpose as a ranging instrument at the most critical stage.

The same principle of invisibility should influence the site and construction of command posts to enable them to be tenable as long as possible.

As regards communications, the center whence telephonic messages radiate should not be apparent, neither should the receiving ends of the radii advertise themselves in any way. Flag signaling in any exposed situation will only draw fire.

Where facilities exist, failing telephonic communications, cyclist orderlies could be very advantageously employed.* I am not aware that the pneumatic tube system for despatching messages, similar to that largely used by the Telegraph Department in London has been tried, but it seems to me that it is worth trial; the air can be kept under high pressure in cylinders, so that the center would not be encumbered by machinery for supplying the compressed air, and the advantage of delivering a written order over that of a verbal one spoken through a telephone, while guns are being fired and shells bursting in the vicinity, is incalculable.

To my mind, an up-to-date fortress with works, etc., laid out on the principles which I have endeavored to describe, has nothing to dread from an artillery point of view from the fire of a fleet; the only thought that need trouble the defenders would be, that the ships would not approach close enough to allow their guns to penetrate the "vitals;" but this is an almost groundless fear, for they must come in close if they mean business.

A fortress can be brought nearer to the requirements of modern times by making works to fit the guns, than by making guns to fit old and obsolete batteries. Now what will be the "battle formation" of ships attacking a fortress? Will they move or anchor? We may safely assume that until they have overpowered the fire of the defence, they will take advantage of their mobility, and will move at such a speed as will permit of their making good practice and prevent them from becoming too easy targets for the opposing guns. They must then, if they move, have room in which to move about; consequently the number of ships actually engaged at any given range will depend on the sea room at that range. They will endeavor to get the greatest possible effect out of their armament and be careful to keep up a continuous fire without masking each other's guns. Therefore, the formation, when the real fighting begins, must be in a single line. Each ship will then conform to the movements of the one ahead. The whole fleet will sweep across the front of the portion of the fortress attacked, and when the leader can no longer effectively fire, each ship will turn round and the procession will recommence, with the former sternmost ship now acting as leader. A slight variation from this would be effected if each ship followed the exact course of the preceding one, and the leader retained her position as such, describing a circle ellipse, or figure of eight. It would not be so satisfactory

* Suggested by another officer.

a maneuver as the first, because the rearmost ships will mask the fire of the leaders, or *vice versa*, at some point of their course; while by the other plan, the ships could keep up their fire, even when turning round.

We may also assume that they will preserve the same formation all through the action, as a good deal of signalling and maneuvering is necessary to change it, which is not likely to be attempted under a heavy fire.

The range at which these maneuvers will take place, will depend on the plans of the Admiral of the Fleet and on his instructions. He might like to run in close and have 15 minutes of it, or he might commence at long range and work in close, firing all the time. The attack further might be in one long line or broken up into sections; but once under fire of the fortress, and replying thereto, the ships must move in one of these two ways, or after a similar fashion.

From the fortress point of view, we should have a succession of ships passing through the arcs of fire of the different works and groups. In that case as a general instruction we should open fire on the leader and follow her right through the arc; then pick up the next one entering the arc and follow her through, and so on to the last ship, keeping each one under fire as long as she remains in the arc of the group and is not masked by the following ships. This would happen when they were circling in the arc of fire of guns of low command. Should any particular ship become disabled the fire commander will specially order such guns as he may consider best for the work, to turn their fire on to her and complete her discomfiture.

Thus we see that all through the fight up to "close ranges," the defenders, owing to the tactics of the enemy, will be constantly chasing one object after another, through their arcs of fire. Consequently the fewer the orders as to choice of objective issued by the F. C. or section C. R. A. during the action, the better. A change of objective means a temporary cessation of fire, while identifying the new objective, so although such a change is occasionally imperative, yet as long as the ships he wishes to be attacked are receiving all the attention that the Fire Commander desires, he will do well, after the engagement has commenced to allow the Battery Commanders to carry on against them as far as possible on lines fixed beforehand. Fixed lines, but not rigid ones. Any divergence should be regarded as a possible factor in the problem, and its effect only weighed and noted by the Fire Commander. Whether this divergence is due

to imbecility or genius on the part of his subordinate ought to be well known to the former, and his action in the matter will depend on his knowledge of the offender's idiosyncrasy. A well-timed, happily resulting fire might change the fortunes of the day, and it would be quite wrong for any subordinate, quick enough to appreciate an opportunity, not to take full advantage of it; although the necessary orders had not reached him. The various links in the chain of command should be taught to consult their brain pans, and not the telephone.

In answer to the question, will the ships anchor? I say, No! except at close range, and then only if, owing to their heavy armor they consider they are protected from the fire of the fortress or there be not sufficient sea-room at that range to admit of the maneuvers of the necessary number of ships it is considered desirable to bring into action there.

As regards the identification of ships. It will be obvious that this will only be of importance in a "broadside" fight—(if I may use the term)—*i. e.*, when the attackers are not exposed to plunging fire from guns on high sites, it will be unimportant when they are exposed to a "deck" attack, *i. e.*, when the *personnel* and unarmored structures are under a plunging fire.

The following points then appear to be requisite to enable a sea fortress to resist the "secondary" attack of an opposing fleet:

1. Invisibility of armament, range-finding and other installations.

2. High angle and plunging fire from ordnance with high command.

3. The employment of the P. F. at "close" range using "P. F. predicting."

4. Constant rehearsals of all possible forms of attacks.

Up till now we have dealt with the considerations of the attack on, and defence of, a Coast Fortress, from a purely artillery point of view as affected by the guns with which the fortress is provided, but before dealing with the aspects of the "primary" attack we must consider the manner in which torpedo-boats added to the defensive resources of the fortress influence the problem.

As I have said before, the attack of a fleet on a Coast Fortress will not be pushed home unless either the weakness of the defence invites it or when the fleet is fulfilling the *rôle* of Field Artillery in a battle on land by preparing the way for the "primary" attack. But the qnestion as to whether the fleet will or

will not push to "close" range will be greatly affected by the presence or absence of torpedo-boats in the defended area of the fortress attacked.

This will be apparent from the following consideration of the aspects of a "primary" attack on a Coast Fortress.

The "primary" attack will consist of either an attack by torpedo-boats, or boat attacks.

The object of a torpedo-boat attack would be the destruction of ships lying under the protection of the guns of the fortress.

To secure effective results from the torpedoes it will be necessary for the torpedo-boats to approach close to the object of their attack.

To enable them to do this without their being destroyed by the fire of the fortress, and of the fleet attacked, the attackers must either engage the guns of the fortress and fleet and push the attack home, when under cover of a heavy fire and smoke the torpedo-boats will dart in and endeavor to sink the ships at any cost to themselves; or under cover of darkness, or thick weather, the torpedo-boats will endeavor to elude the vigilance of their opponents and quietly steal in to effective torpedo range. Having effected their purpose they will trust to the confusion of a successful attack to make good their escape.

As regards the first form of attack it will be obvious that if the attacking fleet advance sufficiently near to enable their torpedo-boats to act effectively, they are themselves exposed to a counter attack from the defenders' torpedo-boats, which is just as likely to be effective.

Further, the time of action of the attacking fleet is limited by the fact that the effective range (to use an artillery expression) of a first-class torpedo-boat is about 100 miles from its base of operations, consequently the attacking fleet in the hours of darkness must be at such a distance from the fortress as will ensure its own safety from torpedo attacks.

The attackers cannot therefore commence their operations until some considerable time after sunrise, and they must run out to sea again with a sufficient margin of day-light to enable them to get out of striking distance of the defending torpedo-boats before darkness sets in.

If, during their operations then, any of their ships are disabled, in the event of an unsuccessful action, these must fall into the defender's hands, as they will perforce be left to shift for themselves, and are thus exposed to capture or destruction.

From this it will be seen that this form of attack on ships

lying under the guns of a Coast Fortress provided with first-class and other torpedo-boats is difficult and dangerous. Where the lines of approach are few and restricted the risk is further increased, but where the attackers have to fight their way in through a narrow channel, defended by modern skill, and fight their way out again the risk becomes enormous.

The task of the defenders will be to use their utmost endeavors to defeat the "secondary" attack by delaying the advance of the attacking fleet, taking into consideration the importance of time to it, and inflicting the greatest possible damage to it during its advance, but once the "primary" attack has developed by the appearance of the attacking torpedo-boats within effective range, every other consideration must give way to the vital necessity of destroying them before they can arrive at striking distance of the ships they menace.

The most dangerous form of torpedo warfare and the most to be dreaded is when torpedo-boats advancing from a distant base, under cover of darkness and thick weather, steal in unperceived to effective torpedo range.

In this form of attack the chances are greatly in favor of the attackers, and the only real safeguard would be to so restrict the lines of approach as to enforce the torpedo-boats to pass through narrow openings in a specially constructed mole or breakwater behind which the protected ships are at anchor. The approaches to these openings should be brilliantly illuminated by electric light, while the openings should be protected by Q. F.'s and heavy guns firing case shot and closed by floating booms or chains drawn across them.

From this then it would appear that ships anchored under the guns of a Coast Fortress, which is provided with first-class and other torpedo-boats, are not exposed to the first form of torpedo attack by night. They are so exposed by day.

If no defending torpedo-boats exist they are exposed to this form of attack by day and night.

They are always exposed to the second form, unless effectually protected from it.

The other phase of a "primary" attack may be considered under two headings.

1. Boat attacks pure and simple.
2. Attacks on booms and mine-fields.

As regards 1. These attacks may assume a variety of forms, amongst them we may instance:

a. An attempt to land a party undetected at one place to

destroy or capture while the attention of the defenders is diverted by an attack elsewhere.

b. Boats landing parties at night with the object of "rushing" a place or work immediately on arrival or at dawn.

c. Boats sent in to capture a place or to destroy *matériel* under cover of the fire of the attacking fleet.

The presence or absence of torpedo-boats as adjuncts to the defence will obviously influence this form of attack, as these considerations will affect it in a precisely similar manner. The features of the defence will be:

To prevent a landing.

To prevent any further operations after the landing has been effected.

In addition to the supporting fire of the fleet, which will be continued as long as possible, the defenders will also have to undergo the field gun, Q. F., Maxim and rifle fire of the attacking boats.

But once a boat attack appears imminent, it must be treated as the main attack and every arrangement made to meet it.

Care, however, must be taken to distinguish between a real attack and a "feint," as the object of the attacker might be to cause the premature disclosure of the means of defence against this phase of the attack, with the intention of crippling it with his main fire.

Should a landing be effected, the operations are at once converted into land operations, and the defence must be continued by infantry fire, assisted by the movable armament acting as Field Artillery.

As regards 2. Booms may be destroyed by shell fire, or by boats under cover of the fire of the attacking fleet.

Mine-fields may be similarly cleared by boats either by creeping or countermining.

The defenders must therefore keep the ships at a distance, and failing this, engage the boats and destroy them before they can do any damage.

In this second phase of the primary attack also, the presence of torpedo-boats will prevent any night operations and it will further materially influence their scope and character by day.

Major O. ROWE, R. A.

PROFESSIONAL NOTES.

ORGANIZATION.

Separation of Field and Fortress Artillery—Austria.

The separation of field and fortress artillery in Austria is now an accomplished fact. Henceforth they will constitute two entirely distinct arms of the service. The officers now attached to the staff of the artillery will be assigned either to the field or to the fortress artillery, or else they will enter one of the technical corps.

—*Revue de L' Armée Belge*, March-April.

TACTICS, STRATEGY AND MILITARY HISTORY.

General Dragomiroff.*

The Russian general, Dragomiroff, who was brought into notice again last fall by his attendance at the French grand maneuvers, is without doubt one of the most prominent and able of the Russian general officers. In case of war he is to be the general-in-chief of the army of Kiew, and in these times of peace he holds the governor-generalship of the military district of that name, in which are stationed four Russian army corps, three brigades of tirailleurs, and a number of Cossack troops and other troops of special character. Michael Iwanowitsh Dragomiroff was not recognized until rather late in life as destined to become one of the most prominent leaders of the Russian army. The first part of his military career was passed in the General Staff and on foreign missions. Born in 1830 at Konolop in the government of Tshernigow, Dragomiroff entered in 1844 the military school then known as the "Regiment of the Nobility." In 1849 he was appointed an officer in the Semenowski regiment of the Guard, and in 1854 he entered the General Staff Academy, where he received for his acquirements the golden medal, an honor which has been thus far conferred upon but two officers. In 1856 he was assigned to the General Staff of the Guard Corps. In the following year he was sent on a military mission to Paris, and went from there to Belgium and England, and afterwards to Algiers, where he studied at first hand the teachings of the master in the art of war whom he most delights to honor, Marshal Bugeaud. In 1859 he made his first campaign on the side of the French in the Piedmontese army, and before the year was over he returned to Russia to accept a chair in the General Staff Academy, his *alma mater*, and one of whose most brilliant scholars he had been. At home he was already well known by his articles and pamphlets, in which he opposed the general tendency to conduct all military training according to Prussian models, took up the ideas of Souwóroff, and demanded that in military training the methods employed be such as appeal not to the body, but to the spirit, in order properly to develop the sense of duty and the feeling of patriotism and self-sacrifice. From his lecture chair in the academy Dragomiroff was enabled

* See a translation from *Nord und Süd* in United Service Magazine, Philadelphia, September, 1894.—ED.

to set forth his views and instill them into his pupils, and thus accomplish a complete change in the education and training of the Russian officers and soldiers. However, he had no idea of devoting himself permanently to teaching and aspired to put his principles to practical use. In 1869 he was assigned to the position of Chief of the General Staff of the Division of Kiew and four years later he was placed in command of the 14th Infantry Division. With this division he distinguished himself in the passage of the Danube in the campaign of 1877. This action is still fresh in men's memories. The crossing of the broad stream was an act of daring, the honor of which belongs essentially to the commander of the 14th Division. The position selected for the passage of the Danube was practicable only with difficulty: before the bank could be reached dangerous marshes had to be crossed, and on the farther shore lay other marshes. Consequently, the Turks did not expect the enemy at this point. Trestle bridges were constructed in the soft ground and a bridge of boats 1,000 meters long laid across the stream itself. Under the protection of a gun-boat flotilla the work was completed, and the 8th corps, Dragomiroff leading with the 14th division, set foot on Turkish soil. Later the division under Dragomiroff took part in the celebrated crossing of the Balkans, which was and remains one of the most glorious deeds of the Russian army. At Shipka Pass a bullet shattered the General's knee and passed through the foot of his adjutant. This wound compelled Dragomiroff to give up active duty for some time. In the following year he took charge of the General Staff Academy, with all the authority conferred by his brilliant service on the Danube and in the Balkans, a position which he retained until 1889. In that year he was assigned to the command of the military government of Kiew, one of the most important commands in the Russian army. He was enabled there to put in execution his previously expressed views, and under his active and powerful impulse the army of Kiew became one of the best in Russia. Although the discipline may be severe, it is a fatherly one, and the General exerts himself above all things to arouse in his officers and men the spirit of initiative and the feeling of patriotism and self-sacrifice, which Souwóroff knew so well how to infuse in the Russian soldier. Dragomiroff attains this result not only by direct contact; he has written much,—books, brochures and small pamphlets, couched in popular phrase, helping to make the service regulations clearer and more impressive. He has taken into account not only the officer but also the common soldier, and has compiled for the latter an excellent *vademecum*. It contains only five or six pages, but embraces all that is necessary to tell the soldier. Hundreds of thousands of copies of the little print have been disseminated in the Russian army, and it is interesting enough for us to quote a few passages. "You must look upon the subdivision to which you belong," he says, "as a family, and see in your commanding officer a father, in your comrade a brother, in your subordinate a younger relation, then you will be happy, you will immediately feel at home, and need not trouble yourself about anything else. Think not of yourself, but of your comrades, then your comrades will also think of you. Rescue your comrades, even though you lose your life. Do not expect to be relieved, you will not be relieved, but you will receive support. You will have ample time to rest after you have fought well. Only he is beaten who is afraid. The good soldier knows neither flank nor rear, he always fronts towards the enemy. Take the ammunition of the dead and wounded and add it to your store. In war you will probably neither eat nor sleep to excess; your

strength will be tried to its uttermost, such is war. The work is occasionally hard even for the good soldier; for the poor soldier it is a burden. However, you must remember that if it brings you hard privations, the same is probably the case, and perhaps to a greater degree, with the enemy; you can see only your own trials and tribulations, while those of the enemy you do not see, although they are quite as real as yours. Therefore, never lose heart; the harder it goes with you, the more stubbornly and desperately you must fight; you will be victorious and then you will at once find yourself in better condition, while the enemy will be in worse plight; only he will be saved who holds out to the last. Do not treat the inhabitants of the country you may be in badly, for they give us food and drink. Keep yourself neat and clean, take good care of your uniform and keep your equipments in order. Guard your gun, your ammunition, your hard-tack and your legs more carefully than the apple of your eye. Learn how to put on your foot-cloth properly, and before a march rub your feet well with tallow, it will keep them from chafing." We might go on and quote this entire *vademecum* of the Russian soldier with advantage, for it applies to soldiers of all countries. For the officers Dragomiroff compiled other instructions, in which he set forth the scope and importance of their duties and responsibilities, and at the same time furnished them with valuable works, remarkable for their agreeable and easy style. His handbook for the preparation of troops for battle is a perfect masterpiece, and he has known how to make the dry material attractive by the introduction of correct teachings established by conclusive arguments. The duties of the Colonel, for example, he has summed up in a masterly manner. "The word of the Colonel," he says, "is the law of the regiment—he cannot shirk the responsibility for his actions by throwing it on his subordinates, but must assume that responsibility fully and completely, and be mindful of the fact that he is under all circumstances the head and responsible commander of his regiment." In this spirit and tone is every subject handled. When Dragomiroff discusses the rôle of each arm of the service, its relation to the other arms, the management and control of the firing, the methods of attack, he does it invariably in vigorous and telling words, and his teachings deserve to be recognized more widely than merely within the narrow limits of the Russian army.

The labors of General Dragomiroff are, however, not confined to office work; the commander of the army of Kiew also makes his knowledge and experience tell in the practical work in the field, the execution of which he superintends, and the excellence or imperfection of which he passes judgment upon. His criticisims are matters of earnest teaching with him, and he gives them great publicity and wide dissemination, in order that every one may derive some good from them. In them the idea, so dominating with Dragomiroff, viz: to make of the soldier not a mere machine, but a thinking being, a conscious fellow-laborer, striving with him towards the object for which he must sacrifice everything in the interests of his regiment or the army, constantly recurs. Dragomiroff has excellent command of the French language and has set forth the essence of his teachings in that tongue in the *Revue Contemporaine*; he is well acquainted in the French army. His high calling and his prominent military qualifications, as well as the fact just mentioned, make the General the fittest representative of the Russian army at this year's French maneuvers, and this all the more so as the General carries his sixty-four years lightly, and is still very active as proven by his ascent in the

balloon, which, by the way, almost resulted in a serious accident. Considering the undeniable esprit of the General and his capacity to handle the French, the Russian army could hardly have sent a more fitting representative to their maneuvers, and she may confidently expect conspicuous services from the commander-in-chief of the army of Kiew, tried in peace and in war, when the Czar shall call her to arms.

—*Allgemeine Schweizerische Militärzeitung*, January 4, 1896.

DRILL REGULATIONS AND MANEUVERS.

Service of the 12-inch B. L. Mortar and 8-inch B. L. Rifle on Barbette Carriage.

Proposed by Lieutenant T. BENTLY MOTT, Aide-de-Camp, U. S. Army.

In preparing this manual I have tried to keep in view two things:

A drill for heavy guns should not be burdened with too much precision; at the same time, where eight or ten men are working together at a machine, each should be definitely assigned to a certain part of the work.

Officers may at any time be called upon to drill and make ready for actual service large numbers of inexperienced men, and a manual giving each man's duties with some precision would be a saving of time both to the instructor and the recruits. This would especially apply to militia called in to serve heavy artillery.

At the same time, with well trained troops, accustomed to each other and to their officers, I believe that much latitude should be given to the officer fighting the gun as to how he shall carry out the details of his work.

In the Navy, divisional officers have much independence in matters of detail at great-gun drill, and it seems that nothing but good results have ensued. It is therefore suggested that this manual might be followed closely for the purpose of instruction, but in actual work precision should not be made of much importance.

SERVICE OF THE 12-INCH B. L. MORTAR.

1. This piece is served by a chief of detachment, a gunner and six other cannoneers. The detachment is formed in double rank, the chief of detachment, uncovered, on the right of the front rank, the gunner on the left of the front rank, the odd numbers in the rear rank, the even numbers in the front rank, 1 and 2 on the right, 3 and 4 next, and so on.

2. In actual service the men are permanently assigned to the duties for which they are best fitted.

3. To tell off the detachment the instructor commands, CALL OFF. The chief of detachment steps two paces to the front, faces about and repeats the command. Each man calls off, beginning with No. 1; thus, *one*, *two*, etc., *gunner*. The chief of detachment resumes his post.

4. To post the men at the piece, the detachment being formed as above facing to the front and a convenient distance in rear of the piece, the instructor commands, 1. *Cannoneers to your posts*, 2. MARCH.

At the first command the chief of detachment steps two paces to the front, faces about and commands, 1. *Right*, 2. FACE, 3. *To your posts*, and repeats the command MARCH. At the command *face*, the men face; at the command *march*, they step off, the odd numbers, except 5, filing to the right of the piece, the even numbers to the left. Nos. 1 and 2 take post one yard outside and opposite the front ends of the side frames, 6, one yard outside and

opposite the rear end, 3, opposite 4, 4, midway between 2 and 6; the dress is toward the muzzle. The gunner and 5 face and march off with the detachment, taking post facing to the front in rear of the breech and conveniently near it, the gunner on the left, 5 on the right.

5. To reform the detachment in rear, the instructor commands, 1. *Detachment rear*, 2. MARCH, the chief of detachment repeating both commands. At the first command all the men face toward the rear, and at the second they step off, the gunner and 5 falling in in their proper places. The column of even numbers closes in toward the odd numbers; the chief of detachment, when the detachment has gone far enough to the rear, commands, 1. *Column right*, 2. MARCH, 3. *Detachment*, 4. HALT, 5. *Right*, 6. FACE, 7. *Right*, 8. DRESS, 9. FRONT, and takes his own post.

6. The men being at their posts, to change posts, the instructor commands, 1. *Change posts*, 2. MARCH. At the first command all the cannoneers except the gunner face to their left; at the second each man moves forward one post; No. 2 passing in front of the muzzle takes the post of 1, 1 the post of 3, 3 that of 5, 5 that of 6, 6 that of 4, 4 that of 2.

The gunner does not change unless specially ordered, in which case he takes the post of 6.

7. The implements and equipments are arranged for drill or service as follows:

Muzzle cover—Enveloping the muzzle.

Breech cover—Enveloping the breech.

Sponge, Rammer } To the right and rear of the carriage, heads to the front, each resting on a prop.

Gunners pouch and sleeves. } Hanging on handle of translating crank.

Loading tray, lanyard, primer-key, quadrant—At some convenient place near the carriage.

Shell truck with tray attached—Conveniently near post of No. 6.

Slush bucket and brush, four wheel chocks for truck, shell tongs, carrying bar—With projectiles.

Tub of fresh water, two water buckets, wiping and oiling cloths, hand sponge—In some convenient place in rear of the carriage. Projectiles for service are kept on a platform provided with a shoot for launching them into the shell tray. For drill, a dummy projectile may be kept on this platform and launched in the same way, but a service projectile should habitually be used at drill. Dummy cartridges should also be provided.

If an armament chest is provided for each piece, it is kept at some convenient place near the carriage. Whenever any tools are taken from the armament chest during the drill, the chief of detachment will see that they are replaced.

8. The service of the piece is performed as follows:

The men being at their posts, the instructor commands, *take equipments*. The gunner puts on his pouch, and with the asistance of 5, his sleeves, and secures the primer key about his person. The gunner and 5 then remove the breech cover and hand it to 4, who places it folded in rear of his post. No. 2 removes the muzzle cover and places it with the breech cover. No. 6 places a bucket of water with the hand sponge in it near the post of 5. If any cannoneer observes any part of the mechanism to be out of order, he now reports it to the gunner.

[NOTE.—Before commanding LOAD, the instructor causes the piece to be given an elevation of about 45 degrees to simulate the conditions of service.]

9. The instructor commands LOAD. Nos. 3 and 4 facing to the front, seize the handles of the elevating wheels, 1 and 2 unclamp these wheels, 3 and 4 depress the piece as far as it will go, when the gunner commands, CLAMP. Nos. 1, 2 and 6 then go for the shell, 6 taking the shell truck and tray; 2 chocks the wheels, 6 steadies the truck, 1 and 2 launch the shell into the tray. A service projectile will habitually be used at drill. Nos. 3 and 4 go for the cartridge, and returning, stand the case conveniently near the breech. The gunner removes the old primer, opens the breech and examines the mechanism. No. 5 wets the hand sponge, squeezes it out and thoroughly cleans the threads and lower blank of the screw box, the entire circumference of the gas check seat, then the circumference of the gas check and the screw threads. After about ten rounds, or when from any cause the residue has accumulated to any great extent, the gunner calls for the sponge. No. 3 hands it up to 5 and receives it again after 5 and the gunner have sponged out.

10. The gunner seats the loading tray. No. 6 wheels up the shell, 1 and 2 go immediately to the shell hoist wheel, and raise the shell at the direction *hoist away*, and lower the tray at the direction *lower away*, from the gunner. No. 6 receives the tray on the truck and runs it quickly out of the way. No. 5 gets the rammer, launches the shell onto the loading tray, reverses the rammer and, as soon as the shell hoist is out of the way, places the rammer head against the shell.

11. All the cannoneers now run to the rammer, lay hold, and at the command RAM from the gunner, set the shell home vigorously. All the cannoneers quit the rammer except No. 5, who replaces it on the prop. Nos. 3 and 4 hand the cartridge to the gunner, place the case out of the way and resume their posts. The gunner inserts the cartridge so that its base shall barely clear the gas check seat, removes the loading tray, hands it to 6 to replace, closes the breech, screws in the primer and commands AIM.

12. No. 6 attaches the hook end of his lanyard to the shell hoist and walks away with the lanyard to the rear. Nos. 1 and 2 lay hold of the traversing handles and traverse according to the gunners commands, RIGHT, LEFT, SLOWLY, HALT. At the same time, 3 and 4 unclamp, seize the handles of the elevating wheel, allow the piece to run up to an elevation of about 45° and clamp; then await the further directions of the gunner. As soon as the traversing is finished, 1 and 2 lay hold of the clamp. If the elevation is to be given by quadrant, the instructor gives the elevation for the next shot to the chief of detachment, who prepares the quadrant accordingly and hands it to the gunner. The latter seats the quadrant and commands, ELEVATE, DEPRESS, CLAMP LIGHTLY, CLAMP. Nos. 3 and 4 work the elevating wheel, 1 and 2 the clamp. At the command CLAMP, 1 and 2 clamp hard and call out *all safe*.

13. The gunner hooks the lanyard to the primer and commands READY. At this command, all of the men, except No. 6, run quickly to the chief of detachment, who takes post at a convenient place in rear and forms the detachment. No. 6 stands facing at right angles to the axis of the piece, heels together, right arm as at *attention*, right thumb through the leather ring, left hand, nails up, grasping the slide and holding it about six inches from the knot. At the command READY, he glances along the lanyard and sees that it is taut and free.

14. The instructor commands 1. Number—2. FIRE. No. 6 strikes the knot a sharp blow with his slide, winds the lanyard or leaves it extended on the ground as he may be directed, and joins the detacment. As soon as the piece is fired the chief of detachment, unless otherwise directed, commands 1. *Right*, 2. FACE, 3. *To your posts*, 4. MARCH.

SUMMARY OF DUTIES OF CANNONEERS—12-INCH B. L. MORTAR—SERVICE.

No. 1. *Take equipments.* Stand fast. *Load.* Seize clamp; go for shell, launch shell into shell tray, man shell hoist wheel; help ram; man traversing handle, seize clamp.

No. 2. *Take equipments.* Remove muzzle cover. *Load.* Same as No. 1.

No. 3. *Take equipments.* Stand fast. *Load.* Depress muzzle; go for cartridge and return; help ram; pass up cartridge; elevate muzzle.

No. 4. *Take equipments.* Place breech cover in rear of post. *Load.* Same as No. 3.

No. 5. *Take equipments.* Help gunner with sleeves; receive bucket; remove breech cover. *Load.* Clean breech mechanism; help ram; replace rammer.

No. 6. *Take equipments.* Get bucket of water for No. 5. *Load.* Take truck and go for shell; steady truck; wheel up shell; receive empty tray; run out truck; help ram; place loading tray in rear; prepare lanyard; fire piece.

Gunner. *Take equipments.* Put on pouch and sleeves; remove breech cover. *Load.* Remove old primer; open breech; seat loading tray; help ram; insert cartridge; close breech; screw in primer; aim.

SERVICE OF THE 8-INCH B. L. RIFLE ON BARBETTE CARRIAGE.

1. This piece is served by a chief of detachment, a gunner and 6 other cannoneers. The detachment is formed, told off, posted, reformed in rear, and changes post, as prescribed above for the service of the 12-inch B. L. mortar. The gunner and No. 5 take post on the loading platform, facing to the front, the gunner on the left, No. 5 on the right.

2. The implements and equipments are arranged as prescribed for the 12-inch B. L. mortar, except that the loading tray, lanyard, primer key and sights, are placed on the loading platform. No quadrant is used.

3. The men being at their posts the instructor commands TAKE EQUIPMENTS. The gunner puts on his pouch and, with the assistance of 5, his sleeves, secures the primer key about his person and seats the sight. The gunner and 5 then remove the breech cover and hand it to 4, who places it folded in rear of his post. No. 2 removes the muzzle cover and places it with the breech cover. No. 6 places a bucket of water with the hand sponge in it on the loading platform near the post of 5.

No. 3 gets the rammer and leans it head up in the reentering angle of the right hand-rail of the loading platform, the staff perpendicular to the axis of the piece.

If any cannoneer observes any part of the mechanism to be out of order, he now reports it to the gunner.

[NOTE.—Before commanding LOAD, the instructor causes the piece to be given an elevation of several degrees to simulate the conditions of service.]

4. The instructor commands LOAD. Nos. 1, 2 and 6 go for the shell, 6 taking the shell truck and tray. No. 1 wipes off the shell, 2 chocks the wheels, 6 steadies the truck and 1 and 2 launch the shell into the tray. Nos. 3 and 4

man the elevating wheels, depress to the loading position and go for the cartridge; 3 brings up the front half, 4 the rear half, and place them on the loading platform. They then stand by to pass up the cartridge, after doing which 4 mans his elevating wheel; 3 receives the rammer, replaces it and mans his elevating wheel.

5. The gunner removes the old primer, opens the breech and examines the mechanism. No. 5 wets the hand sponge, squeezes it out, and thoroughly cleans the threads and lower blank of the screw box, the entire circumference of the gas check seat, then the circumference of the gas check and the screw threads. After a number of rounds, or when from any cause the residue has accumulated to any great extent, the gunner calls for the sponge. No. 3 hands it up to 5 and receives it again after 5 and the gunner have sponged out.

6. The gunner seats the loading tray. No. 6 wheels up the shell, 1 and 2 go immediately to the shell hoist crank and raise the shell at the direction *hoist away* and lower the tray at the direction *lower away* from the gunner, and then man the traversing crank. No. 6 receives the tray on the truck and returns it to its place. No. 5 controls the breech so that the shell may enter, seizes the rammer, launches the shell onto the loading tray, reverses the rammer and, as soon as the shell hoist is out of the way, places the rammer head against the shell. The gunner adjusts the shell by hand so that its base just clears the gas check seat; he and 5 then take a long hold and ram the shell home vigorously. No. 5 withdraws the rammer, the gunner takes the front half of the cartridge from 3 and inserts it in the breech. No. 5 rams home this part of the cartridge and hands down the rammer to 3 to replace on its prop. The gunner receives from 4 the rear half of the cartridge and inserts it by hand so that its base shall just clear the gas check seat, closes the breech, screws in the primer and commands AIM, at the same time setting the rear sight for the range.

7. No. 6 attaches the hook end of his lanyard to the hand rail and walks away with the lanyard to the rear. The gunner commands *right*, *left*, *slowly*, *halt;* or *elevate*, *depress*, *slowly*, *halt*, always referring to the muzzle. Small changes in elevation may be given by 5 alone.

8. The gunner attaches the lanyard and commands READY. At this command, 1, 2, 3 and 4 step quickly behind the breech, but stand ready to man the traversing gear if the necessity arises. The gunner and 5 remain on the loading platform or dismount as may be directed. No. 6 stands facing at right angles to the axis of the piece, heels together, right arm as at *attention*, right thumb through the leather ring, left hand, nails up, grasping the slide and holding it about six inches from the knot. At the command READY he glances along the lanyard and sees that it is taut and free.

9. The instructor commands, 1. *Number*—2. FIRE. No. 6 strikes the knot a sharp blow with the slide, winds the lanyard or leaves it extended on the ground as he may be directed. Each man resumes his post.

10. In firing at a moving target, the gunner may be directed to fire the piece. After laying, he hooks the lanyard, corrects his aim, commands READY, steps back on the platform, seizes the lanyard and fires.

SUMMARY OF DUTIES OF CANNONEERS—8-INCH B. L. R.

No. 1. *Take equipments.* Stand fast.

Load. Go for shell; launch it into shell tray; man shell hoist crank, man traversing crank, step to rear.

No. 2. *Take equipments.* Remove muzzle cover.

Load. Same as No. 1.

No. 3 *Take equipments.* Stand rammer in hand rail angle.

Load. Depress piece to loading position; go for cartridge, pass up to gunner; receive rammer, resume post, man elevating wheel; step to rear.

No. 4. *Take equipments.* Receive breech cover.

Load. Same as No. 3, except does not receive rammer.

No. 5. *Take equipments.* Help gunner with sleeves; receive bucket.

Load. Clean breech mechanism; remove breech cover, control breech for entrance of shell; launch shell into gun; help gunner to ram; ram first half of cartridge; hand down rammer.

Gunner. *Take equipments.* Put on sleeves and pouch; remove breech cover.

Load. Remove old primer, open breech; seat loading tray; help ram; insert cartridge, close breech: screw in primer; aim.

NOTES.

The leading position should be marked by painting a line across the trunnions and trunnion beds.

The gun should be horizontal or slightly depressed to aid in ramming the shell home with force. The shell hoist should then be adjusted accurately to the loading position.

With the carriage now in place (1895) at Fort Monroe, the rear elevating wheel is so placed as to make it necessary to raise the breech considerably before the breech block can be swung back without striking the elevating wheel. After loading, the breech must again be elevated before it can be closed. Nothing in the drill provides for this raising of the breech to open and close the same as it is anticipated that this defect will be remedied in the carriages, as may easily be done by lengthening the shaft of the elevating wheel about a foot toward the rear.

Do not *flood* any part of the mechanism with water. It pays to clean the parts *thoroughly* as prescribed in paragraph 5, but the sponge should not be *soaked* with water.

Ram the projectile home with all possible force.

When the gun is fired, No. 5 and the gunner should get well into the corners of the hand rail of the loading platform.

This platform should, and doubtless will, be made a foot wider each way. When the gunner knows at what target he is to fire his next shot, he should (while the loading is being completed) get his sights to bearing roughly on the object to save time in aiming. The armament chest should be permanently kept in some convenient place in the battery.

After about 10 rounds the gunner should squirt some oil in the annular spaces in front of and behind the gas check.

The working parts are supposed to be thoroughly oiled at the beginning of drill or action. Ordinarily they should not need oiling during anything but a prolonged action; of course, should the screw threads, screw box, etc., become gummy at any time, they must be oiled. In any case it is safe to oil them after say 10 shots. When the breech screw is swung back in opening, the translating handle is liable to jump from its vertical position. No. 5 must in every case push the handle back to its vertical position, before the breech is closed, and the gunner should not touch this handle in closing the breech.

It does no harm to lubricate the projectile, but it is not necessary.

The instructor should frequently order the gunner to *sponge out* during the drill, both of gun and mortar, so that the gunner and No. 5 may be taught this operation. It is not laid down as a regular part of the manual of the piece, because in action it would not often be done, and then only by direction.

A service projectile should always be used after the first few drills, with both gun and mortar. To properly ram the projectile home is one of the most important things for the men to learn, and drill with a dummy projectile does not teach them this. This use does not injure the service projectile in any way. The time consumed in removing the projectile is not by any means wasted, and handling and ramming home a service projectile is a vital part of the drill.

EXPLANATIONS.

The aim has been to make the drill of the two pieces as much alike in the duties of the various cannoneers as is possible. There is no reason why this should not be so; a mortar to-day is merely a short gun. It is moreover believed that for the drill of the 10-inch rifle on barbette carriage, only a slight extension of the drill for the 8-inch gun will be necessary. The more nearly all the drills are alike, the better the men will perform their duties at each piece, and the shorter the time needed to teach new men. Six men and a gunner have been assigned to the service of both gun and mortar. As to having more men for the mortar, the above arrangement has the advantage of minimizing the men about the piece, makes the two drills similar and does not reduce efficiency. With a loading bench, such as must be provided, 1, 2 and 6 can place the 1,000 pound shell in the tray as easily as 1, 2, 3 and 4 could do it.

If such a bench is not provided and the shell tongs are used, four men would be as helpless as three, and at least eight men would be needed to handle the shell.

If with a loading bench, it be deemed advisable to have four men to handle the shell, the extra men should be stationed with the projectiles to get one ready for each round, to wipe it, etc. They would be more useful here than standing at the piece in the mortar drill.

As long as the rear elevating hand wheel occupies its present awkward position, much time and trouble are wasted in raising the breech before opening or closing the same, in order that the translating crank may not strike this wheel. If the shaft of the wheel were made about eight inches longer toward the rear, the crank and the wheel would not interfere, and the breech could be opened when the piece was horizontal or slightly elevated, which in actual service, are the positions in which the piece would be loaded. The shot hoist should be adjusted, by means of its screws, to the loading position most usual and convenient in practice, say horizontal, and this position marked by a white line painted across trunnions and trunnion bands. It seems natural to suppose that the ordnance department will, when attention is called to the difficulty above mentioned, alter the length of the shaft of the rear elevating wheel; the drill is therefore laid down as though this defect had been remedied. Of course with the carriage as it stands, the gunner has simply to cause the breech to be elevated sufficient to open and close each time; but it is a great and unnecessary waste of time due to a very small and easily remedied defect of mechanism. A lanyard 75 feet long is provided for use with

these pieces. It may be possible to use it with the mortar, though the necessity for this length is open to doubt. In actual service, no officer in command of a gun would ever use this lanyard with the 8-inch rifle; he would certainly shorten it up if the Ordnance Department continued to furnish it 75 feet long. The department might be interrogated on this point. Active control of the fire of the rifle is difficult with such a lanyard, and firing direct at a moving target, impossible. In the U. S. Navy this same gun is fired by the man who points it and with the gun crew at their post; this too with an open shield and no turret.

The heaviest guns in the navy are fired with their crews standing 2 or 3 feet away; we should certainly be able to do as much, and it is equally necessary for good work. I have therefore provided in the manual that the gunner and No. 5 may remain on the loading platform when the piece is fired. Nos. 1, 2, 3 and 4 are directed to close in toward the breech where they are removed from the blast and are yet available in case the gunner wants the training gear manned. The gunner is directed to screw in the primer before laying, as when the piece is once pointed there should be as little delay as possible before firing. If the projectile is to be lubricated, the lubricant should be kept with the shells and applied by No. 1 before launching into the shell tray. However, lubricant is believed to be unnecessary. The gunner commands *right*, *left*, *slowly*, *halt*, experience having shown me that such cautions as *slowly* and the command *halt* are of great assistance. The words *elevate* and *depress* with arrows for the guidance of the men, are *cast* upon the carriage of the mortar, and should be *painted* upon that of the gun for uniformity and convenience. I have noticed that to most soldiers, *raise* and *lower* applies to either breech or muzzle; *elevate* they seem to know applies to the muzzle; hence these commands are laid down for the gunner.

The rammer-head for both gun and mortar should be made smaller, or the hole in the shell-tray longer, so as to save the time required for reversing the rammer. A large rammer-head has no advantages. The requiring Nos. 1 and 2 to *clamp* at the mortar while 3 and 4 elevate or depress is a precaution founded on experience. I have twice seen the breech get away and run down, while the breech block, which on one occasion was open, barely escaped injury. When a 1,000 pound shell is in the breech, the preponderance is enormously increased, and it would seem of great importance to have two men clamp while two elevate. It increases also the rapidity of laying. The method of posting the detachment, changing posts, etc., has been laid down in detail. Tidball's manual is not now used for the service of any of our guns, and it seems well that the manual for the new S. C. guns should be complete within itself.

Minor changes in the carriages, such as lengthening the shaft of the elevating wheel, enlarging the loading platform, etc., must be made by our Ordnance Department to meet service requirements; we cannot sacrifice our fighting efficiency for the sake of accepting proving ground conditions. My aim has been to make this a service drill useful as a training for battle, and in which nothing is prescribed that would not be done in the actual fighting of the guns. Thus only can the drilling at these guns in time of peace be made a preparation for fighting them in war.

The following letter from Assistant Naval Constructor Dashiell, U. S. Navy, may be of interest to our artillery officers. Lieut. Dashiell has had the advantage of years of experience in firing the 8-inch and heavier guns at the

naval proving grounds; what is far more to the point, he has had much experience in serving these guns at competitive target practice *under service conditions afloat*, where service carriages and projectiles were used and the *time element* given its full importance; no officer of our army has had such experiences combined.

"BUREAU OF ORDNANCE, NAVY DEPARTMENT,

WASHINGTON CITY, June 14, 1895.

Memorandum for Lieutenant Mott, U. S. A.

My dear Mr. Mott:—

"In reply to your questions in regard to the service of the 8-inch gun:

"It is not necessary to wash or sponge out the chamber provided you can get the projectile home without doing so. With a drilled crew I always get the shot home and do not sponge the chamber, the residue does not accumulate much from round to round, if it does, sponge it out of course. Wipe off the gas check and its seat with a wet but not *dripping* marine sponge or waste. As slope or seat is wiped, the same man cleans the threads and lower blank of screw-box. It pays to do this thoroughly. Before practice, all the mechanism should be in good order, oiled like any other machine.

"No oil required in firing, except say every ten shots squirt a little behind gas check and over plug threads if *dry* or *gummy*, but not otherwise, as too much oil on threads may be a bad thing. The men keep their stations on firing, the man who points stands in rear and pulls the string, and while the loading is going on tries to keep the sights bearing by orders to the man at the training crank.

"See projectile is *clean*, not lubricated as it is slippery enough to handle any how, though in competive drills, a little grease on ogive might make the crew think they were hustling. Don't deluge anything with water. My proving ground experts never required more than their natural secretions of saliva for *all* purposes, but of course water is supplied on ships, and there are ponderous drill instructions issued as to its use.

"Keep the gas check clean, with its seat, put plenty of men on the rammer, keep the training going while the loading is being done, and you cant go wrong.

"Always glad to be at your service in any way I can. With regards, I remain

Yours sincerely,

R. B. DASHIELL."

ARTILLERY MATERIAL.

a. Guns and Carriages.

Pneumatic Dynamite Guns at San Francisco.

Pneumatic guns seem to be the favored form of coast defense in the United States, for apart from those erected at Sandy Hook, to which many references have been made in our columns, another form, the design of an inventor named Rix, has been installed recently at Fort Winfield Scott, near San Francisco, and an account of it has appeared in the local press. It seems that this plant has just been tested during the last week, by the government board, and the results have shown that the quality of the machinery and the character of the tests in every way exceeded those made at Sandy Hook during the last installation made by this same company.

The Rix air compressors are two in number and of the duplex pattern, each of about 400 h.p. capacity. The air is compressed in the first cylinder

to 75 lb. to the square inch, and is thence taken into a cooling tank, containing about 1,000 running feet of 1-inch copper pipes, in which the air is cooled from the temperature of its discharge from initial cylinders, which is about 320 degrees, to the temperature of the water or thereabouts. It is delivered to the intermediate cylinder at about 65 degrees in temperature, and is there compressed in a single-acting ram to about 400 lb. pressure. The air is thence taken again into the intercooling chamber, through about 400 feet of copper pipe, and is cooled again to the temperature of the water, and is delivered to the high-pressure cylinder at the same temperature as to the intermediate cylinder.

In the third cylinder it is compressed to 2,000 lb., the air being delivered at a temperature of about 358 degrees. This is conducted to the third intercooler, where the temperature is reduced to about 65 degrees, and is thence conducted to the storage reservoir. The engines which drive this compressing plant are of the Meyers cut-off style, and are extremely well balanced and well constructed; in fact, the cards and the results show that these compressors have a mechanical efficiency of about 85 per cent., and throughout the system there is a saving of 36 per cent. over the work required to compress the air to 2,000 lb. adiabatically. The amount of air delivered per hour at 2,000 lb. is about 460 cubic feet, which is more than ample to keep the machines in operation; in fact, during the test one machine would have been sufficient to have maintained the number of shots.

One feature about this whole compressing plant is the facility with which the air is cooled. Each cylinder has a number of independent circulations, notably the high-pressure cylinders, where four circulations are introduced, each independent of the other, viz., a circulation for the head and valves, two circulations for the cylinders, and a circulation of water within the ram itself while it is in operation. This preserves the packing of the ram, and at the same time contributes largely to the cooling of the air during compression. During the operation of the plant, the initial temperatures, that is the temperatures of the inlet for each air cylinder did not exceed 70 degrees, while the temperature for the discharge of the air varied from 290 to 350 degrees.

The mechanical efficiency of the plant, that is, the ratio of the indicated horse-power in the steam cylinders to the i. h. p. of the horse cylinders, was 85½ per cent., which is quite high, considering the fact that the machines were not designed for extra economical use, the idea being to provide for the Government something that can be operated easily and which was not easy to get out of repair.

After passing the intercoolers the air is delivered into twenty-four storage tanks, each 16 inches in diameter by 24 feet long, containing about 650 cubic feet. These tanks are connected with the firing manifolds. These manifolds are of complex construction, designed so as to admit the air to any or all of the guns, and to admit the air to any or all of the storage tanks. The air in the storage tanks is maintained at 2,000 lbs., while the air delivered to the storage tanks of the guns is at 1,000 lbs. pressure.

The guns themselves are very interesting in their character. They weigh about 70 tons each, above their foundations, are 50 feet long by 15 inches in bore. They can fire projectiles of any caliber from 8 to 15 inches, the difference in caliber between the full and the sub-caliber being made up by wood pistons in four sections which surround the projectile, and which fly off mmediately upon leaving the gun. These projectiles vary from 11 feet long

and 15 inches in diameter in the full caliber, to 8 inches in diameter and 8 feet long in the sub-caliber. The latter carry about 100 lbs. of dynamite explosive, and the former carry 500.

The guns are easily traversed around the whole 360 degrees of circle by an electric motor placed within one of the supports of the gun, and the connections of this motor are so arranged that it will also operate the mechanism for elevating and lowering the muzzle. The gun is ranged from 0 to 35 degrees, which is considered ample for all ordinary purposes. The greatest range obtained with the 8-inch projectile, carrying 100 lbs. of dynamite, and which flies under a loss of pressure of about 100 lbs. was 5,000 yards and slightly over. This may be considered the maximum flight for usual purposes. The 10-inch is proportionately less, and the 15-inch projectile which carries 1,000 lbs. of dynamite and weighs 1,100 lbs., has a range of from 2,000 to 2,500 yds. All of these projectiles may be thrown accurately; in fact, there is no reason why, with the same pressure, the same amount of air wasted in the throwing of the projectiles, the same weight of projectile and the same character of projectile, the atmospheric conditions being the same, it should not land practically in the same place. The results at Fort Point demonstrated this. The 8-inch projectiles were thrown from 5,000 to 5,070 yards, and were placed in the target, 70 yards in length by 30 yards in width, which far exceeded the Government requirements.

The material used in these projectiles is nitrogelatin, composed principally of nitroglycerin and guncotton. The whole projectile is of an intricate mechanism, and has provisions made for exploding the charge either by direct impact, side impact, or by a delay of from one to three seconds. These projectiles are expensive, probably costing $1,000 each, and their capacity for destruction is fully proportional to their expense. In the test at Fort Point, the 15-inch projectile at 2,000 yards threw up a column of water 350 feet to 400 feet high and 100 feet in diameter at the base, showing conclusively that it would be amply capable to destroy, within an area of 100 feet, the largest man of war.

—*Arms and Explosives*, February, 1896.

Test of ten-inch guns.

The second of the 10-inch finished guns, made by the Bethlehem Iron Company, Bethlehem, Pa., on their contract to furnish 100 such guns to the Government, was tested at the company's proving grounds last week before representatives of the Ordnance Department, with very satisfactory results. Projectiles weighing 575 pounds were used. A new smokeless powder used sent the projectile with a speed of 2010 feet per second and a pressure of 27,000 pounds, with a charge of 106 pounds of powder. A charge of 271 pounds of brown prismatic powder sent the projectile 1997 feet per second, with 38,500 pounds pressure. Every part of the gun was made at Bethlehem.

—*The Iron Age*, June 11, 1896.

b. Armor and Projectiles.

Tests of Armor Plate.

A 12-inch and an 8-inch plate, which had formed parts of groups of armor manufactured by the Carnegie Company, and which had been rejected by the Ordnance Inspector on account of defects, were fired at the Indian Head Proving Grounds, on Wednesday. The primary object of the test was to

ascertain what the shells could do against plates of the double forged character. The most the 12-inch shell could do was to break off a corner of the plate, through the impact, and the 8-inch shells produced a back bulge. As a result of the trial, Captain Sampson proposes to change the specifications for the ballistic test of shells for acceptance so as to give the manufacturers a greater chance of having their product pass the required trial. The 12-inch shell was a Wheeler-Sterling experimental projectile and was manufactured under the contract entered into between the Government and the Wheeler-Sterling Company last November. It was given a velocity of 1,800 feet per second and struck the plate in the upper right hand corner, breaking off a section. It broke into fragments, but portions of the shell succeeded in getting through and fell behind the structure. Had this plate been supported by others, as on board ship, ordnance experts say that the shell would have done no damage, but would have smashed up on the face of the plate.

Two 8-inch shells were fired, one of the Wheeler-Sterling type, and the other of the Carpenter variety. Both shells penetrated the plates several inches, producing a back bulge and breaking up, the bases falling in fragments in front of the structure. Captain Sampson concluded, as a result of these tests, that it would be necessary to increase the velocity for firing 12-inch shells in acceptance tests from 1,662 feet per second, for which the contract now calls, to 1,850 feet per second, and for the 8-inch shell the velocity would have to be much higher in proportion. We are told that the shell manufacturers informed the Department last November, before the contract was entered into, that they felt sure of their ability to manufacture shell which, with forty per cent more velocity than the old requirements called for in testing projectiles against oil-tempered plates, would be able to penetrate to the length of their own caliber into a harveyized plate. The Department considered this statement somewhat exaggerated, but took the manufacturers at their word and made specifications in accordance with it, increasing the velocity, however, ten per cent greater than they asked. The experiments which are now in progress at the proving grounds are for the purpose of developing a temper in the shell which will perforate the double forged armor. The results have so far been a complete victory for the armor, and speaks well for the character of plate on board our modern men-of-war.

In addition to the tests mentioned at the proving grounds, a sample of 6-inch smokeless powder was fired, which gave a velocity of 2,600 feet per second. A bursting charge of smokeless powder was placed in a 6-inch shell and fired. The results showed that the smokeless powder had a greater bursting energy than the ordinary powder, but the advantage is not great enough to compensate for the extra expense in its manufacture to which the Government would be put in case it decided upon its adoption for this purpose.

—*Army and Navy Journal*, June 6, 1896.

Formulae for Calculating the Perforation of Armor.

Captain Tresidder, the well well-known member of Brown's Armor Plate and Steel Works, last year suggested a formula for perforation which might, he urged, be adopted with advantage internationally, on the following grounds: (1) Close agreement with actual results obtained at various velocities; (2) theoretical soundness; (3) simplicity. There is considerable support for the claims thus advanced—that is to say, this formula gives results for high velocities which are much more nearly correct, so far as we have evidence, than do the recognized British formulae of Maitland or Fairbairn. For

low velocities, we believe the last named formulae, which are practically identical, give good results—better, we are inclined to think, than Tresidder's; but in the present day high velocities are much more important than low ones, because the former are more likely to be employed. Then, again, without question, Tresidder's formula is more simple than others. He has also embodied it in a slide rule which is an actual luxury for those who have to calculate perforations. With regard to theoretical soundness, authorities do not appear willing to admit that Captain Tresidder's claim is proved. He has not had much opportunity of advocating his views, and mathematicians are slow to be convinced on a question like this, so that at present the formula stands on its working merits, and the working merits of any formula now are difficult to determine fully, because firing ordinarily takes place against steel plates treated and hardened in such a variety of ways as to make comparison very difficult.

So far as we can speak with confidence, the whole question stands as follows: We have in past years fired at comparatively low velocities at wrought iron until experience enabled us to arrive at a trustworthy formula for these conditions. Such a formula was obtained by a combination of such elements as are theoretically sound with such empirical terms and corrections as caused a fairly correct result to be obtained over a certain range of conditions. As armor developed, difficulties increased. Steel, chilled iron, and steel-faced armor replaced wrought iron. If these always yielded in the same way as wrought iron, that is, by perforation, it would be easy to arrive at a relation between the resistance of any particular steel plate and that of wrought iron of the same thickness, but when plates yield by fracture the conditions are greatly changed. For example, in perforation, the smaller the diameter of a shot, the smaller is the hole it needs to make in order to pass through, and the less is the work required to make such a hole. If, on the other hand, the plate yields in preference by fracture, it is a question if the diameter of the shot enters into the calculation. It appears probable that the action is the splitting action of a pointed wedge struck with the plate, and both plate and shot generally break without a hole the size of the shot's transverse section being made at all. Chilled iron and wrought iron offer the extreme examples of what were then termed "hard" and "soft" armor, the former yielding wholly by fracture, the latter wholly by perforation. Probably the former action depends mainly on the total striking energy of the shot, affected, no doubt, also by its tenacity, on which depends the amount of work delivered before the shot breaks. The latter depends directly on the striking energy, and inversely on the diameter of the hole to be made, that is, the smaller the hole the greater the penetration. How widely the powers of perforation and of fracture differ may be seen from the fact that for many years there were on board the *Nettle* two guns available for testing plates, an old-fashioned 10-inch gun and a new type 6-inch piece. The perforation of the two was about equal, the smaller gun attaining to an equality with the heavy old-fashioned one, by having less work to do in making a 6-inch hole than the heavy shot had to perform in making one of 10 inches.

For the work of fracture the small projectile had no such advantage, and it is probable that efficiency of the two shots might be nearly in proportion to their respective striking energies, and these were nearly in the proportion of two to one; so that while the 10-inch and 6-inch shot were able to perforate about the same thickness of soft armor, the former delivered about double the

shock of the latter on hard armor. As armor developed further, it generally took an intermediate form, yielding partly by perforation and partly by fracture, and this may be said to be the case at the present time. Calculation also becomes more difficult from the liability of the shot to break against the hard face. As we have asked before now, who can calculate what a tool may do in the act of breaking? We may certainly understand how the effect may be greater under some conditions than others. For example, at a high velocity a shot may perform work before the line of least resistance is found, and thus cause surprise by behaving much better than at a lower velocity. On the other hand, at a still lower velocity, the shot may not break at all, and thus a worse result may be obtained at an intermediate velocity than at either a very low or very high one. These effects have been seen in experiments; we may conjecture why, but any approach to calculation is difficult. A question of this kind can only be dealt with systematically. The elements must be separated and investigated one by one. The first step needed is to ascertain the laws relating to perforation of wrought iron at the high velocities which have now come in. At present formulæ which have been empirically adjusted, so as to give good results over a certain range of velocities, are employed for those much higher with very little guidance as to their suitability. The little evidence we have is to the effect that the English official formulæ give perforations which are far too small; indeed, at Shoeburyness on one occasion a 6-inch shot, fired even at the moderately high velocity of 2,378 foot-seconds, passed clean through plates 17 inches thick, and went on about 1,600 yards, when by the old English formulæ it should have only perforated a 16-inch plate, and should not have entered nearly 16 inches into a 17-inch plate. Krupp's formula, and that of De Marre, appear to be much more correct for high velocities; but we have very scanty data to support them. The relation borne by the respective formulæ to each other is best seen by tracing the curves showing the results they give. The diagram herewith exhibits the perforations given for the 6-inch gun firing a 100-pound projectile by the formulæ of Fairbairn, De Marre, Krupp, Tresidder, and a Gâvre formula.

The ordinates give the perforation in inches of wrought iron due to the velocity in feet-seconds registered along the abscissa. The figures and points of registry are those taken and worked out by Captain Tresidder in his pamphlet "Notes on Formulæ for Armor Piercing." These are as follows:

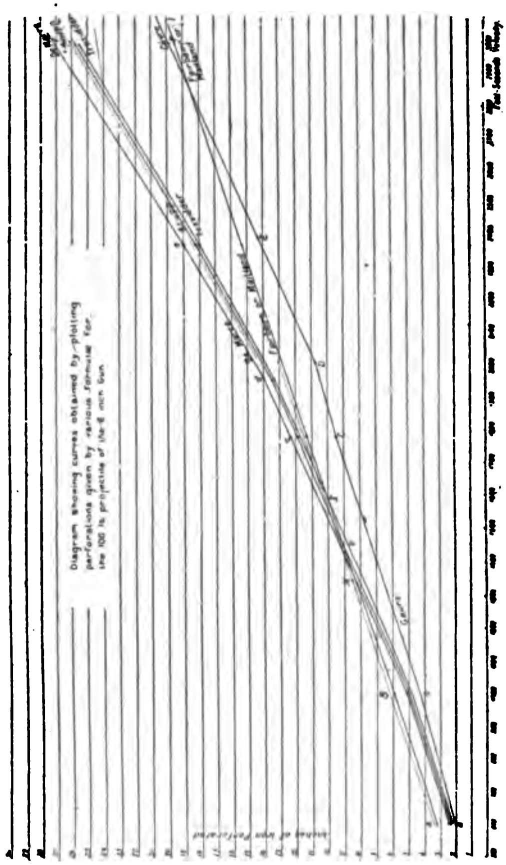
Projectile.	Striking Velocity f. s.	Perforation in inches by Fairbairn.	De Marre.	Krupp.	Tresidder.	Gâvre.
6-inch shot of 100 ℔.	600	3.2	2.30	2.30	2.28	2.00
"	1000	5.9	4.98	4.95	4.90	4.17
"	1780	11.2	12.15	11.80	11.64	9.45
"	1950	12.4	13.93	13.48	13.35	10.78
"	2380	15.3	19.00	18.22	18.00	14.38
"	3000	19.5	27.05	25.80	25.47	19.98

On the diagram the curves pass through the points calculated and plotted at the different velocities, these points lying on or between A *a*, B *b* and C *c*.

Fairbairn's, it will be seen, gives the highest result at low velocities, but soon falls below most of the others, the curve crossing that of De Marre at X about 1,350 foot seconds, Krupp at Y at about 1,460 foot-seconds, and Tresidder at Z at about 1,600 foot-seconds.

From about 1,200 to 1,750 all the variations in the results fall within an inch, but at 3,000 foot-seconds Fairbairn gives 6½ inches less than De Marre, which,

as has been repeatedly pointed out, is a monstrous discrepancy. The Gâvre formula gives also strangely low results throughout. We think, however, that this formula has been abandoned generally in favor of that of De Marre. Those then with which we are most concerned are the formulæ of Fairbairn or Maitland, De Marre, Krupp and Tresidder. The first has been long used



officially, and is not yet actually discarded. Krupp appears to agree with our Shoebury trial better than De Marre's, and Tresidder gives practically very nearly the same results, the difference mainly being that in Krupp's the element of weight tells more, so that with a long projectile with great weight in proportion to its calibre, Krupp would give greater perforation. Tresidder's formula is commonly written thus, for working by logarithms:

$$t^2 = \frac{W v^3}{d} \times \frac{1}{\log^{-1} 8.8410},$$

where t = the thickness in wrought iron in inches, W the shot's weight in pounds, v the striking velocity in foot-seconds, and d the diameter of shot or calibre of the gun in inches. Krupp's formula, using the same notation, is:

$$t^{\frac{4}{3}} = \frac{W\,v^2}{d^{\frac{5}{3}}} \times \frac{1}{\log^{-1} 5.7776},$$

Raising all Krupp's terms to a power of $\frac{3}{2}$, we get

$$t^2 = \frac{W^{\frac{3}{2}}\,v^3}{d^{\frac{5}{2}}} \times \frac{1}{\log^{-1} 8.6664},$$

This obviously approximates nearly to Tresidder's formula.

It is very desirable that the subject of perforation of wrought iron at high velocities should be investigated, not by firing on a large scale, when only a few rounds can be allowed on the score of economy, but with some small piece, when, at comparatively trifling expense, whole series might be obtained. A well planned series would, at all events, give sound data for the scale on which it was carried out, and furnish a formula which would be gradually tested by every round fired on a large scale, and those who have most experience in these matters believe that it would be found to hold good. It might be possible after that to devise something to teach laws of fracture, although this is difficult and far less important than perforation.

In the meantime, we can only act on what data we have before us. It is not to be expected that we should give up using formulæ for the low velocities for which they have been proved good. For high velocities, unfortunately, there is evidence that their use causes gross mistakes. The most natural course to take then would be to keep to our old Maitland or Fairbairn formula up to 1,450 or 1,600 foot-seconds, at which points it agrees with Krupp and Tresidder respectively. Here we might "shunt," as it were, on to one of these curves, and use the Krupp or Tresidder formula for the higher velocities.

There is, however, an objection to such a course—namely, that service tables exist which it is undesirable to alter unless we know that we are right in doing so. Now, in the present state of our knowledge, we have no certainty that we are correcting for the better until the difference becomes a large one, when it is necessary to act. On the whole, then, the best present course is to let our tables stand unaltered up to 2,000 foot-seconds velocity. This covers all but the newest guns. For velocities over 2,000 foot-seconds we may be confident that Krupp's or Tresidder's formula is much nearer the truth than the old ones, and we are inserting new velocities for new guns rather than making corrections in our existing tables. There remains the evil that a projectile striking at a velocity just below 2,000 and one just above 2,000 foot-seconds are calculated on different systems, and a wide gap exists between them. This is shown on the diagram by the dotted line which takes the course we suggest, and abruptly leaves the Fairbairn curve for that of Tresidder at 2,000 foot-seconds; but perhaps it is a good thing that we should have an inconsistency made apparent like this, to remind us of our unsatisfactory condition of ignorance. At all events, we can suggest nothing better at the present time.

—*The Engineer*, (London) April 24, 1896.

On the Preparation of Armor Plates and the Krupp Armor Trials in December, 1894 and March, 1895.

A noteworthy article appeared under the above title in *Stahl und Eisen*, September 1 and 15, 1895, the contents of which are here given, partly in extracts and partly word for word.

After the author, in the introduction, gives a brief account of the various trials and steps in improvement which have brought the manufacture of armor-piercing projectiles to the present perfected form of steel projectile, he enters upon his subject proper: the discussion of the surprising progress which the manufacture of armor plate has made in the last few years.

All armor manufacturers calling to their assistance vast material means and unceasing scientific investigation, are everywhere striving for the lead. In consequence of this, the question as to which system should have the preference, that of face-hardening or that of steel alloy without face-hardening, has been decided much sooner than was at first expected.

Although the question of the kind of armor plate is settled, there are still many different views as to the proper chemical composition of the steel: with the exception of England all nations prefer nickel steel to pure carbon steel. *St. Chamond* uses with good results chromium in addition to nickel in the steel alloy, but in the United States the experiments with nickel-chromium alloy did not prove satisfactory, and have therefore been discontinued.

After giving a variety of views and opinions on the use of nickel steel he continues as follows:

"In this connection the formation of blowholes in nickel steel is a matter of some interest. The presence of blowholes gave rise to the troubles in the Carnegie Works, which raised such a commotion last year. Employes of the aforesaid works informed the government that the blowholes in the armor plates delivered by the works had been artificially concealed. The trial of the plates proved that the blowholes did not affect the resistance of the plates. Krupp plates have verified this conclusion. The former, which were exhibited in Chicago, had many blowholes, some of which were quite large." * * * "Innumerable trials, in which plates of this kind were thickly covered whith shots, had produced the conviction that this material, in spite of its blowholes, was not easily cracked. And as it possessed, moreover, considerable hardness, it was not deemed necessary that it should be free from blowholes. Since that time the Krupp Works have succeeded in producing a much better material for armor plates, which possesses the good qualities of the older material, but in a higher degree, as is evident from the trials described at the end of this article, but which is at the same time practically free from blowholes." * * *

"Captain Sampson says nickel seems to make the carbon more sensitive to hardening, therefore nickel-steel plates face-hardened in water are hardened to depths at which ordinary steel plates show scarcely any increased hardness. Not alone this, the face-hardening can also be conducted with less danger to the plate."

"The distrust of the efficiency of the Harvey process, called forth by the failure of Harvey plates of 40 to 45 cm. in trials made in America within the past year, has given place to a feeling of greater confidence. There is no doubt that throughout the entire process of armor plate manufacture causes are at work which may lead to failure, and these are only occasionally and then quite accidentally detected and understood, so that it would appear that the engineers engaged in this industry will have plenty of inducement and find plenty of opportunity to make improvements for an indefinite time to come. The Americans say that for face-hardening even the casting must be selected with greater care than for oil tempering. During the cementation the carbon readily unites with metallic oxides and gases, always present

wherever defective casting has caused blowholes, vesicles, minute channels and scaly structure to be formed, and produces effects that are apt to leave behind, in the treatment to which the plate is subjected in the rolling mill, in the press or under the hammer, fine fissures and flaws, which, in the hardening of the plate in water, may give rise to cracks. The latter are often the indications of a lack of homogeneity in the metal, which results from a separation of the constituents (especially in the case of large castings), caused by the blocks having been cast at too high a temperature and cooled very slowly."

* * * * *

In spite of all these difficulties, which can be overcome, it is true, to a certain extent by experienced engineers, the great armor works on both sides of the Atlantic appear to have made up their minds to adhere to the principle of face-hardening, whatever may be the manner in which the carbonizing and hardening may be conducted in the future.

The author, after giving a brief sketch of the plants of the various armor works, continues by describing the carbon process:

"The plates receive a certain excess of thickness to allow for the combustion which takes place in the carbonization. It was discovered in America that a film of oxide on the face of the plate delays the process of carbonization and has a deleterious action on it, hence this film must be carefully removed before placing the plate in the cementation furnace. A sand blast has been used successfullv for this purpose.

"In place of the carcoal dust originally used by Harvey, a mixture of wood charcoal and animal charcoal (waste from filters and sugar refineries) is used in America. But as it was discovered that a too rapid introduction of carbon into the steel destroys its fine grain and produces a crystalline texture, like that of cast iron, which impairs the strength of the steel and the resisting power of the armor plate, the face of the plate is first covered with a layer of pure animal charcoal, 12 to 15 mm. thick, and over this is placed the charcoal mixture."

* * * * *

The author then refers to the *Grambow* process, in which hydro carbon gas is used for carbonizing the face of armor plates, gives a brief description of the *Creuzot* process, based on a similar principle, in which illuminating gas is used for this purpose, and then continues:

"What results the Creuzot works obtained by this process is not known to us. Jaques thinks that Krupp uses the same or some similar process, not yet made public, to which he probably owes his remarkable success. Undoubtedly the use of gas in carbonizing insures a more uniform carbonization, because the gas penetrates to all parts equally, whereas carbonization with solid coal naturally involves many difficulties and uncertainties, as every experienced workman, who has to do with the cementation process, knows. If it were possible to obtain by this newer process a deeper carbonization in a shorter time and at a lower temperature than heretofore (in the Harvey process, which requires 15 days, a temperature of 1000° to 1200° C. is kept up, and the carbon penetrates to a depth of about 75 mm.), this would be a considerable advantage not only as regards cost, but also as regards increased resistance of thick plates."

"In America it has been proposed to cut small furrows in the face of the plate before carbonization in order to increase the surface exposed to the carbon, to hasten the carbonization and to increase the depth to which it takes place; notwithstanding the fact that, owing to our not being able to control

the action, it was to be expected that apparently similar conditions would not necessarily produce similar results. A deeper penetration of the carbon would be particularly advantageous in the case of thick plates."

In a number of trials between 1882 and 1890, Gruson established the fact that the fine hair-like fissures formed in face-hardened armor plates during the hardening process, and which are confined to the hardened layer, in no way reduce the resistance of the plate, and have no effect in determining the extent or direction of those cracks which are produced by the impact of projectiles, a discovery which was verified by the Krupp trials of December 15, 1894, of which we will speak more in detail further on. This discovery led Whitworth to cover the upper surface of a test plate with a net-work of artificial fissures crossing in all directions. The excellent behavior of this plate in its trial upheld the correctness of his proposition to prevent the cracking of plates by means of artificial fissures on their face. His proposition found positive support in the behavior of three plates, which, having been rejected on account of their surface cracks, were fired upon till they were destroyed. One of these plates, strange to say, showed a greater resisting power than a similar plate with a sound surface. This phenomenon was explained by the fact that the cracks permitted the cooling liquid to penetrate below the surface and hence the hardening effect penetrated deeper.

As in the case of the carbonization, there should be a *gradual* passage from the hardened face into the tough back of the plate; a sudden transition from the hardened layer to the softer and tougher back layer would facilitate the chipping off of the hardened layer from the impact of projectiles, and correspondingly reduce the resisting power of the plate. The hardened layer, *i.e.*, the metallic layer, which, on account of its hardness cannot be worked by cutting instruments, is about 12 to 20 mm. thick in American plates, 20 to 30 mm. in Krupp plates.

The author then proceeds to discuss separate trials, taking up first that (described in the *Iron Age* of March 21, 1895) of a curved turret plate, 355 mm. (14 in.) thick for the battle-ship *Oregon*, prepared by the Carnegie works and tested at the Proving Grounds at Indian Head. The plate was reforged after carbonization, but before being face-hardened. The principal data of this trial are:

Shots. No.	Caliber. cm.	Velocity of Impact. m.	Strik'g Energy. mt.
1	25.4 (10 in.)	566.5 (1858.6 feet)	3714.0
2	25.4 (10 in.)	588.0 (1929.1 feet)	4003.0
3	30.5 (12 in.)	566.0 (1857.0 feet)	6289.3

In the first two shots the projectiles (Carpenter shell) broke. The third shot (Wheeler Sterling projectile) penetrated the plate, the oak backing 355 mm. thick, and 3.65 m. (4 yards) of sand, but without producing any cracks in the plate. This trial showed that the plate had a greater power of resistance than was required of a 14-inch plate by the United States Navy, and greater than such plates usually have.

The author continues:

"The Americans have a right to extol the excellent behavior of this plate, one of the best of the products of American manufacture. It also furnishes an excellent opportunity for comparison with the products of the Krupp

works, which, on the 16th of March last, fired at a 300 mm. (11.81 inches) face-hardened nickel-steel plate with the 30.5 cm. gun. This plate was 55 mm. thinner than the American plate, and the striking energy of the projectile was 6078, therefore 211 mt. less, but it was not pierced! The projectile entered to a depth of 60 mm. only, and would have gone through an unhardened steel plate 501.8 mm. thick, while the American would have pierced one of 516 mm., or only 14 mm. more; therefore *the* 300 *mm. Krupp plate very materially surpasses in resisting power the excellent* 355 *mm. American plate.*"

In addition, the author gives detailed accounts of the later trials of Krupp armor plates, which are cited below, partly in the words of the author, partly in tabular form, amplified by the remarks of the *Marine Runschau* on these trials.

The Krupp Works prepared armor plates according to a process of their own, the trials of which were conducted by the Imperial German Navy on the 15th and 17th of December, 1894, and the 15th and 16th of March, 1895:

KRUPP FACE-HARDENED NICKEL-STEEL PLATE NO. 413 II.

Thickness, 146 mm.; length, 2.73 m.; height, 1.5 m.; weight, 4,580 kg. The plate had received on its face, during the hardening process, 26 fine hair-cracks, of various lengths, running down perpendicular to the surface (see Plate I).

The plate, resting on an oak backing, not bolted, 60 cm. thick (two 30 cm. sections) was fastened to a forged iron bulkhead with two inner skins of 20 mm. each, by means of ten 65 mm. bolts.

The 15 cm. shells struck the plate at an angle of 87°, the 21 cm. shells at right angles.

No. of shot.	Gun.		Projectile.		Distance of plate from muzzle of gun.	Velocity of projectile at target.	Striking energy of projectile.	Thickness of plate which projectile would perforate.		Depth to which projectile penetrated.	Effect on projectile.
	Cal. cm.	Length.	Kind.	wt. kg.	m.	m.	mt.	Ordinary steel. mm.	Wr'ght iron. mm.	cm.	
I	15	L/30	Steel armor-piercing shell. L/3.5	51	120	475.7	588.2	*204.3	284.0	1.4	Broke up.
II	15	L/30	"	51	120	576.7	864.5	268.7	381.5	—	"
III	15	L/30	"	51	120	528.5	726.0	237.5	334.0	—	"
IV	21	L/22	Steel armor-piercing shell. L/2.5	95.0	121	437.2	925.5	196.0	271.6	3.5	"
V	21	L/22	"	95.0	121	500.9	1215.0	238.0	334.8	—	"

* The calculation of the perforating power, according to the author, is based on the French equation of *De Marre:*

$$v = 1530. \frac{a^{0.75}}{p^{0.5}}. E^{0.7},$$

in which v is the velocity of impact of the projectile in m., a the diameter of the projectile in dcm., E the thickness of the plate in dcm., p the weight of the projectile in kg.

EFFECTS ON THE PLATE.

Shot I.—In the indentation made by the projectile, which was 180 mm. in diameter, five fine, concentric surface fissures appeared, from which thin pieces pealed off during the subsequent shots: The plate was free from cracks; no change was apparent in the fine fissures caused by hardening.

Shot II.—The projectile punched out a piece of the plate, which was afterwards found in the first section of the backing. The shot hole had a diameter of 180-200 mm., and chippings from its walls on the right side were carried along to the rear. Although the shot struck in the midst of the hardening cracks, the latter remained unaltered, and no new cracks appeared.

Shot III.—Pealing off over a space 240-400 mm. in diameter around the point of impact. Although the left side of the flaking off coincided with one of the hardening cracks, the others remained quite unaltered; no new cracks appeared. On the back of the plate was a convex bulge 50 mm. in height, with concentric cracks at the base.

Shot IV.—Flaking off over a space 300 mm. in diameter around the point of impact. At intervals of 50, 100 and 200 mm. from the edge of the shothole three fine concentric cracks were formed, the origin of which was connected with a bulge on the back 350 mm. in diameter and 25 mm. high. There were, besides, three very fine cracks, only 50 mm. deep, running from shotholes 1, 2 and 3 to the upper and lower edges of the plate, and at shothole 2 also a fine radial crack, crossing the haircracks. In spite of the small depth to which it penetrated, the superior energy of the 21-cm. shells over the 15-cm. shells, transmitted to the plate by the points of the projectiles, was evinced in the crushing and shattering action.

Shot V.—The projectile punched out a section of the plate and broke. One part of the projectile was found in front of the plate, while its head and the other pieces lodged in the second layer of the backing in front of the inner skin. The latter received merely a slight dent from the point of the projectile. Here, along with the fragments of the projectile, were also found the pieces punched out of the plate, the largest of which weighed 15 kg. The walls of the shothole, which had a diameter of 220 mm., were smooth in front, ragged at the back, the fragments torn out having been carried away. The hardened layer to a width of 230 mm. pealed off as far as shothole four. No other cracks were formed.

"Plate 413 II, therefore, withstood a total energy of 4319.2 mt., or 943 mt. per ton of plate, without receiving a through crack. This is a proof of the extraordinary quality of its material, which is the more remarkable as there were already a number of hair-cracks in the hardened layer before the trial began. This trial proves, therefore, that hair-cracks do not in general affect the strength of the plate as regards the formation of cracks and consequently its resisting power. *Hardness and toughness, properties which are generally opposed to each other, are combined here to an extent not hitherto attained.*"

"Whereas English authorities assume that the best Harvey plates, 152 mm.

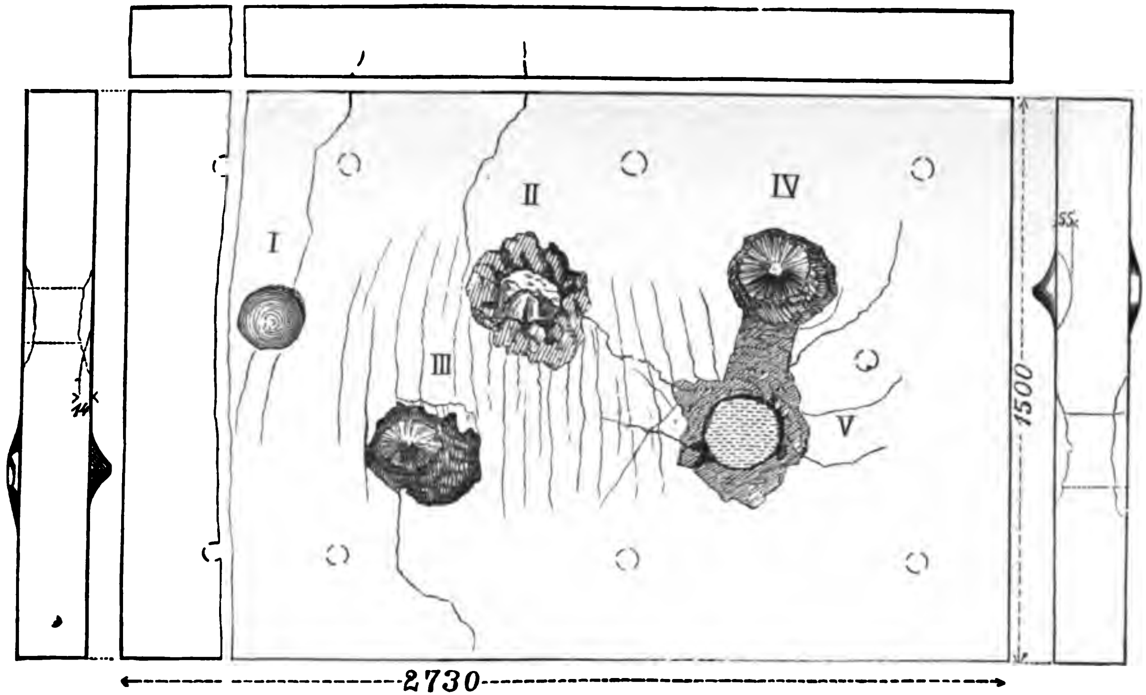
The equation holds good for simple unhardened steel plates; for wrought iron De Marre's formula is:

$$v = 1280.\ \frac{a^{0.75}}{p^{0.5}}.\ E^{0.65}.$$

The coefficients, determined from practical experiments, apply only to an average strength of material, and increase as the resisting power of the armor plate increases. The coefficient may therefore be regarded as an index of the quality of the various plates. But as the resisting power of different armor materials and plates differs very much in the different works, and even in the same works, it has not been found possible to find a coefficient universally applicable to the different kinds of steel.

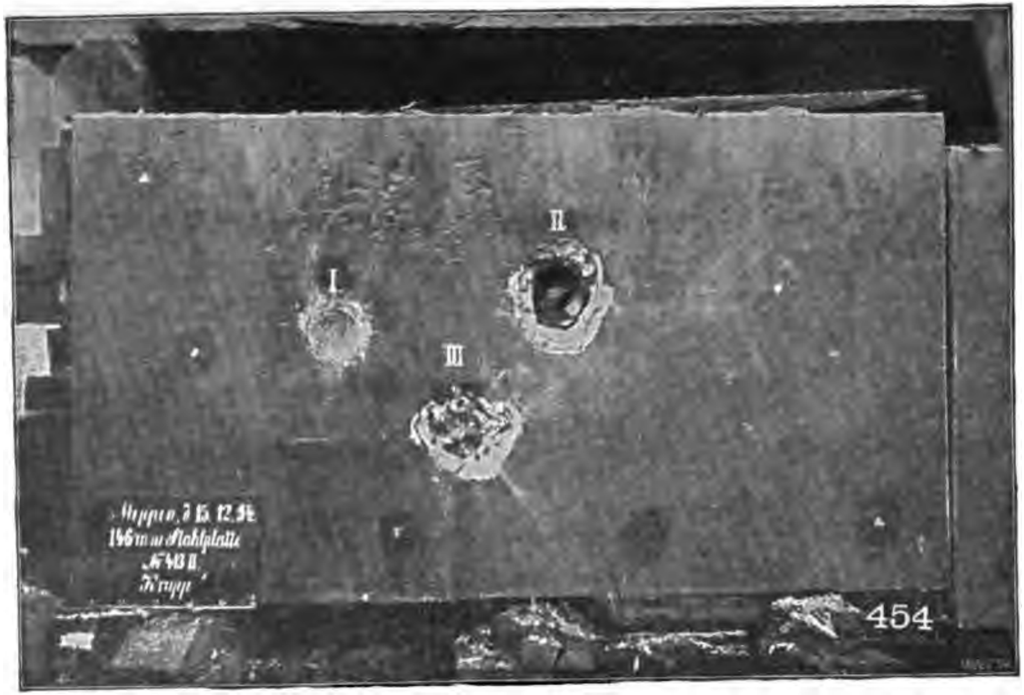
PLATE I.

Hardened *Krupp* 146 mm. nickel steel plate No. 413 II.



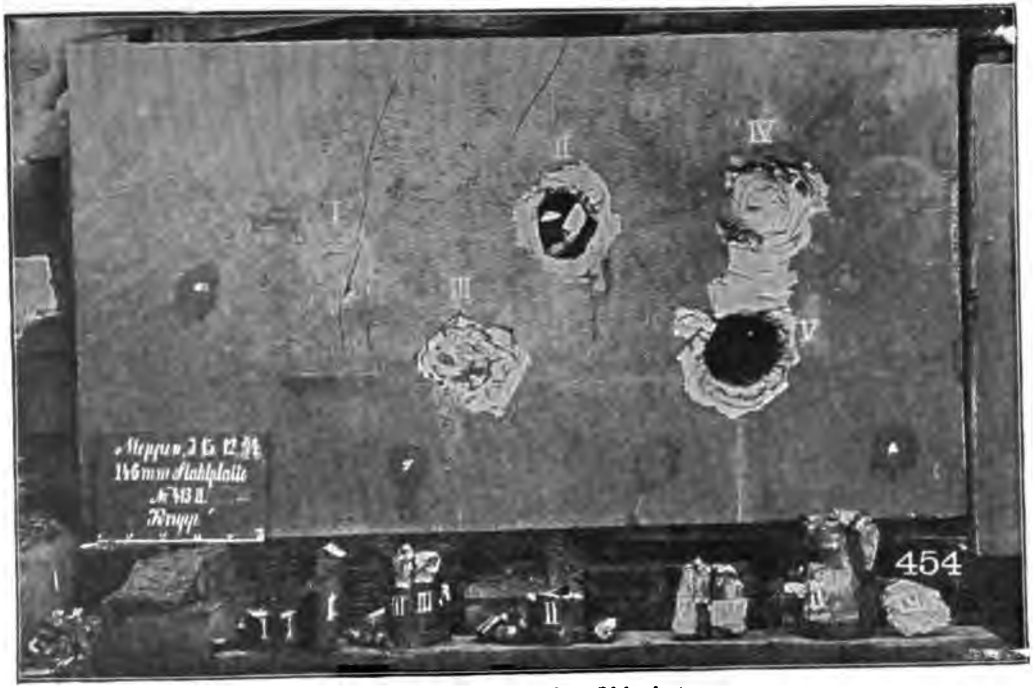
Sketch of plate after test.

Plate II.



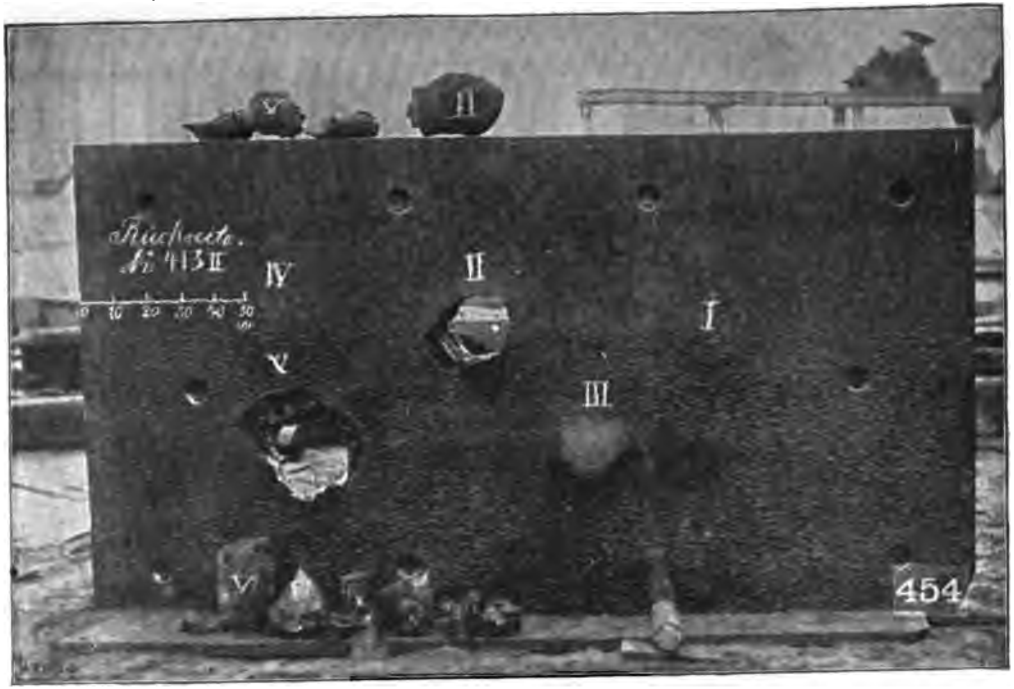
Front face of plate after third shot.

PLATE III.



Front face of plate after fifth shot.

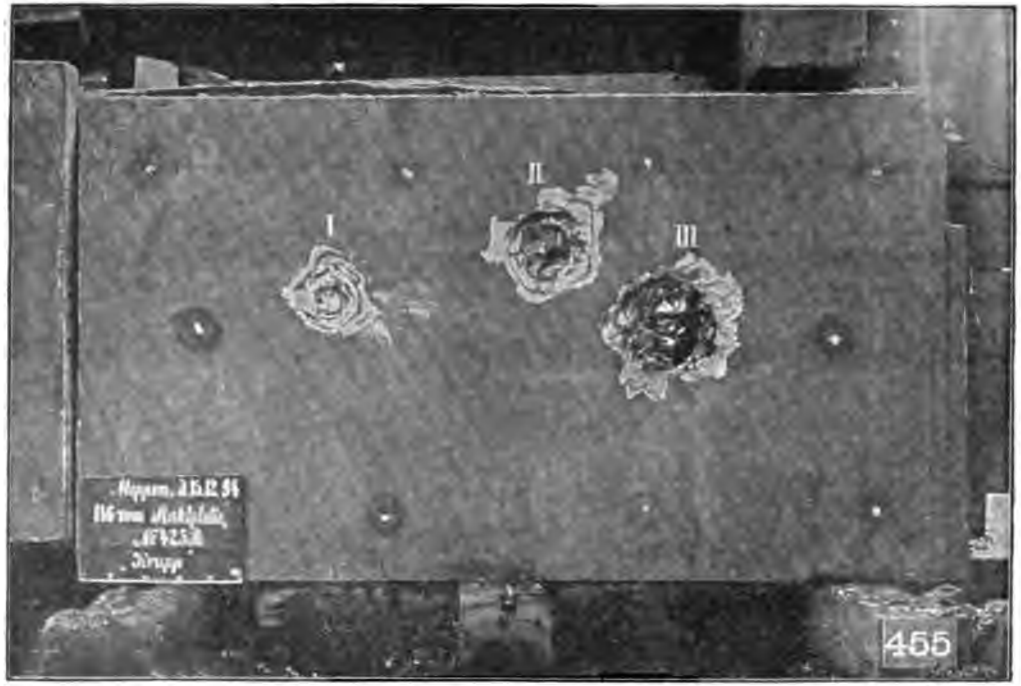
PLATE IV.



Back of plate after fifth shot.

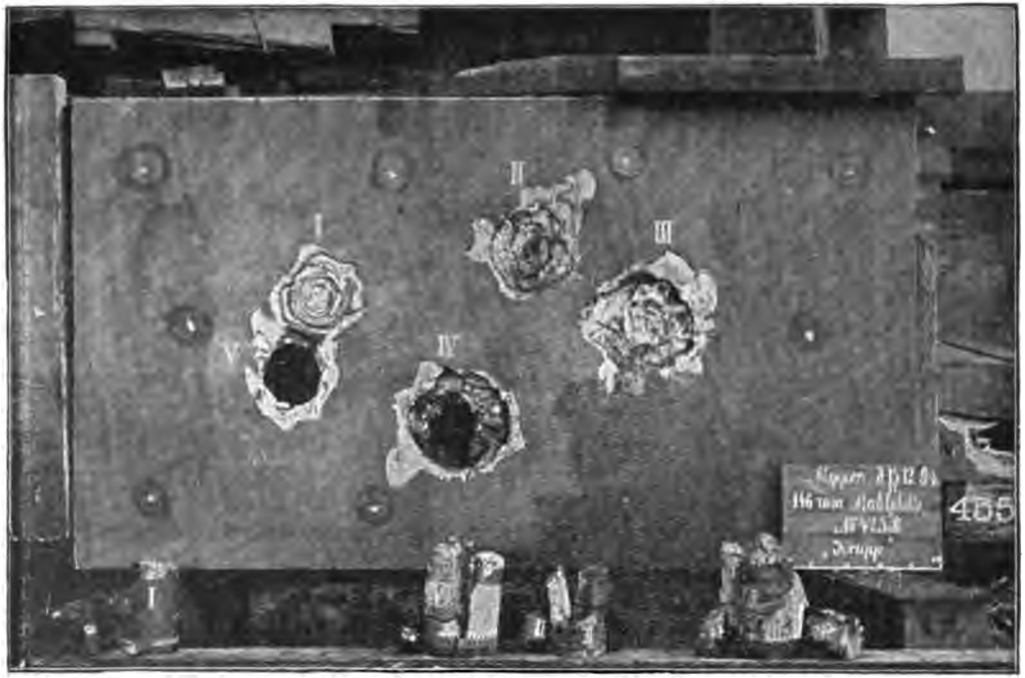
PLATE .V

Hardened *Krupp* nickel-steel plate No. 425 B.



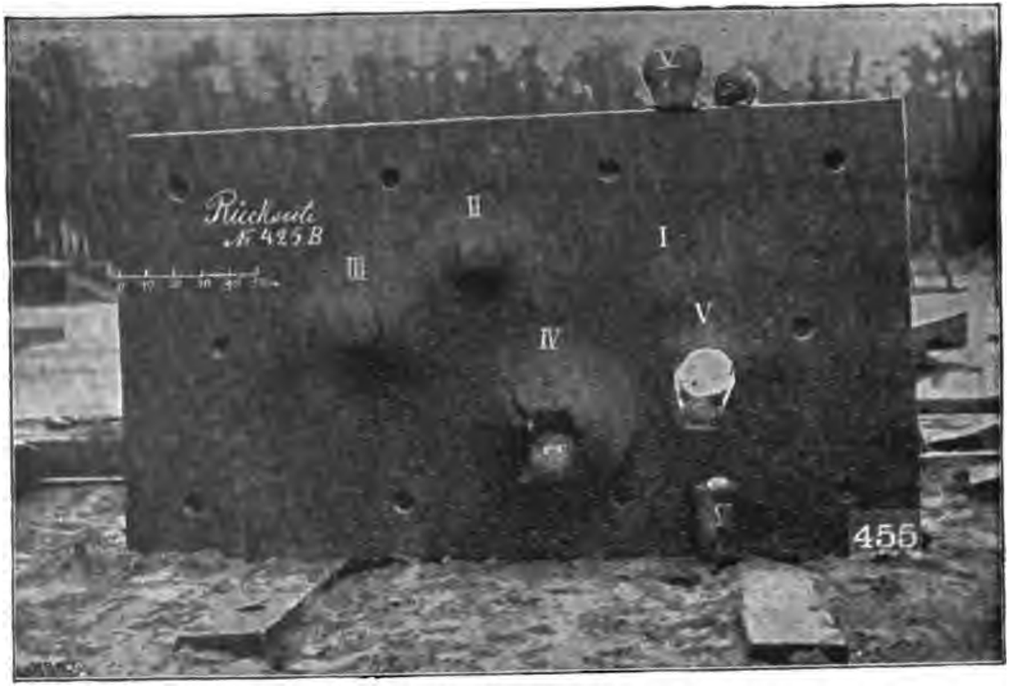
Front face of plate after third shot.

PLATE VI.



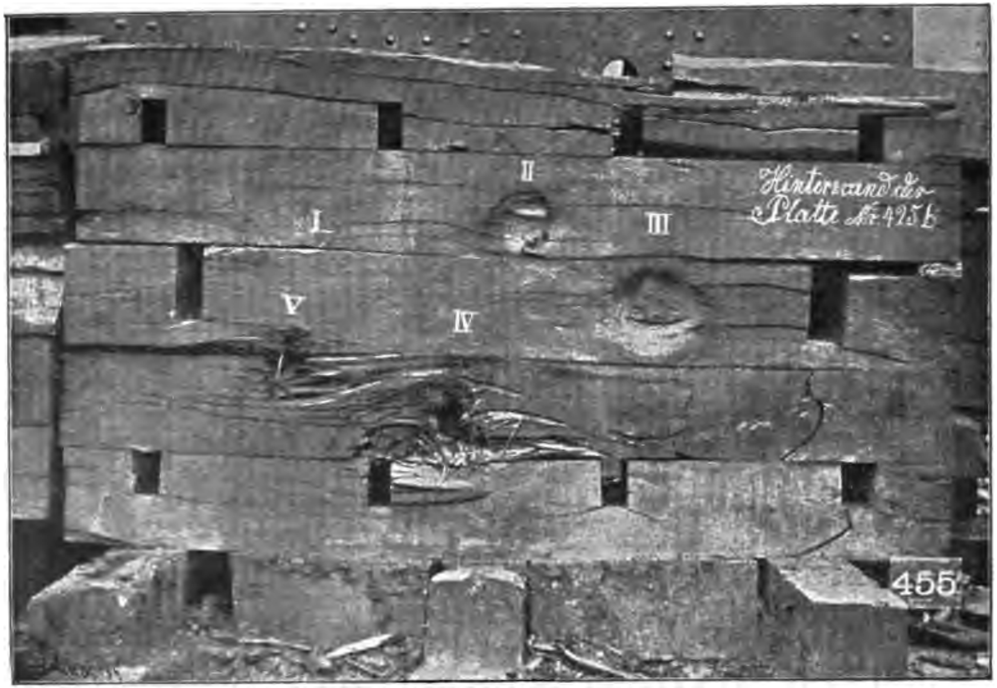
Front face of plate after fifth shot.

PLATE VII.



Back of plate after fifth shot.

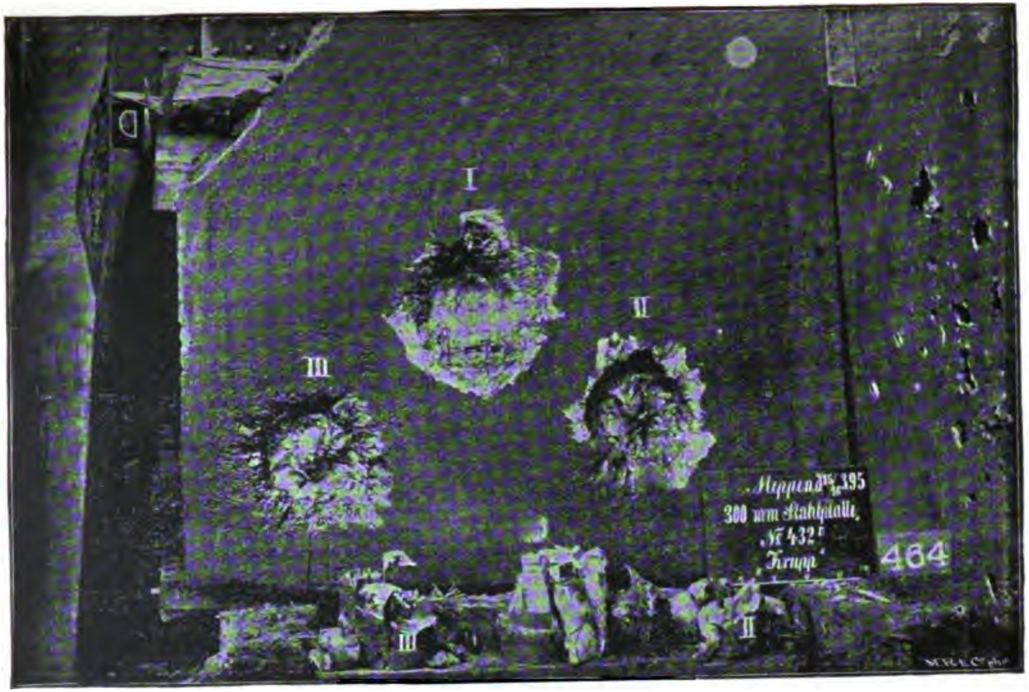
PLATE VIII.



Backing of plate.

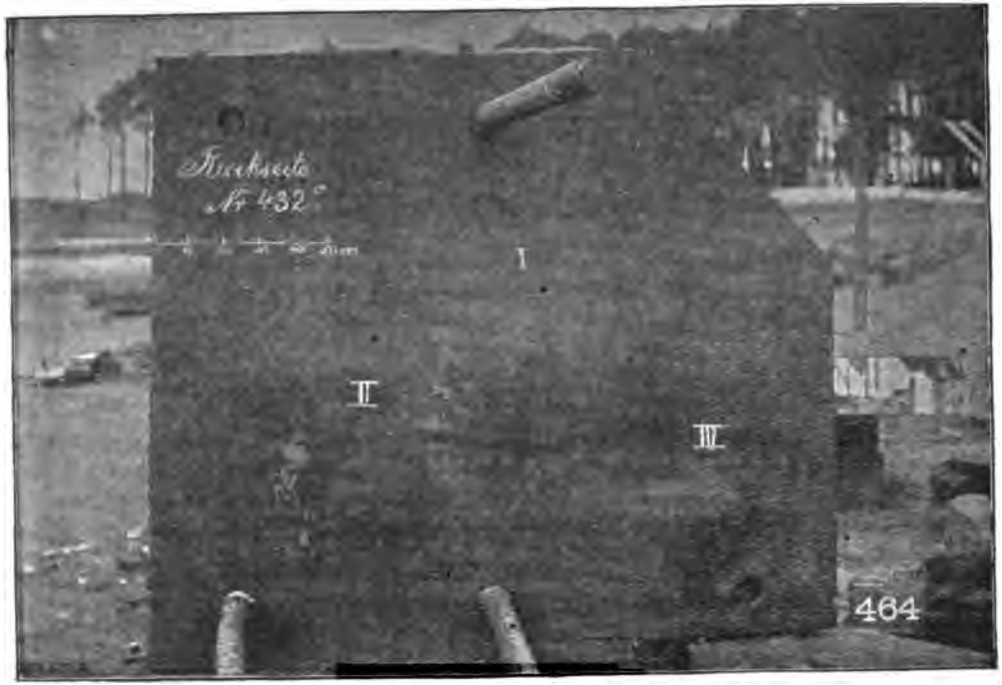
PLATE IX.

Hardened *Krupp* 300 mm. nickel-steel plate No. 432ᵛ.



Front face of plate after third shot.

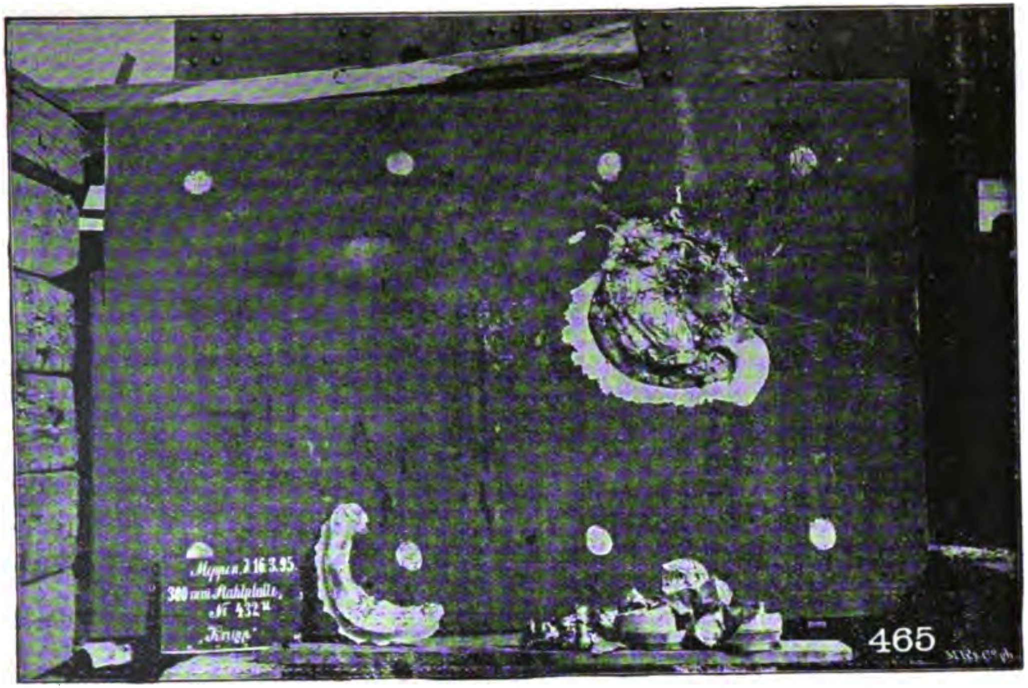
PLATE X.



Back of plate after third shot.

Plate XI.

Hardened *Krupp* 300 mm. nickel-steel plate No. 432ᵘ.

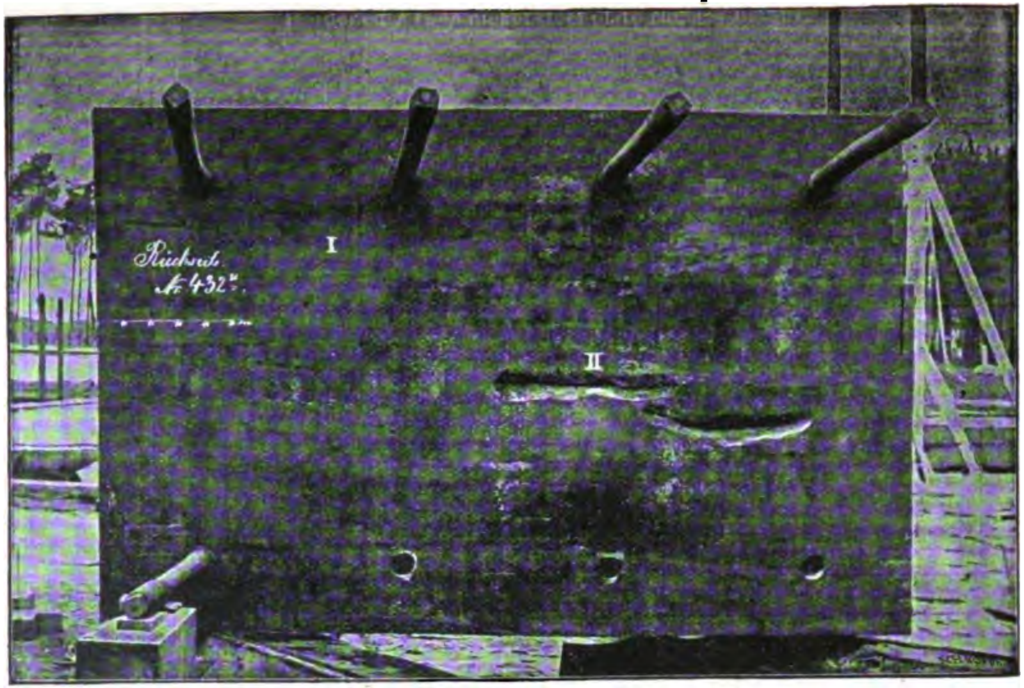


Front face of plate after first shot.

PLATE XII.

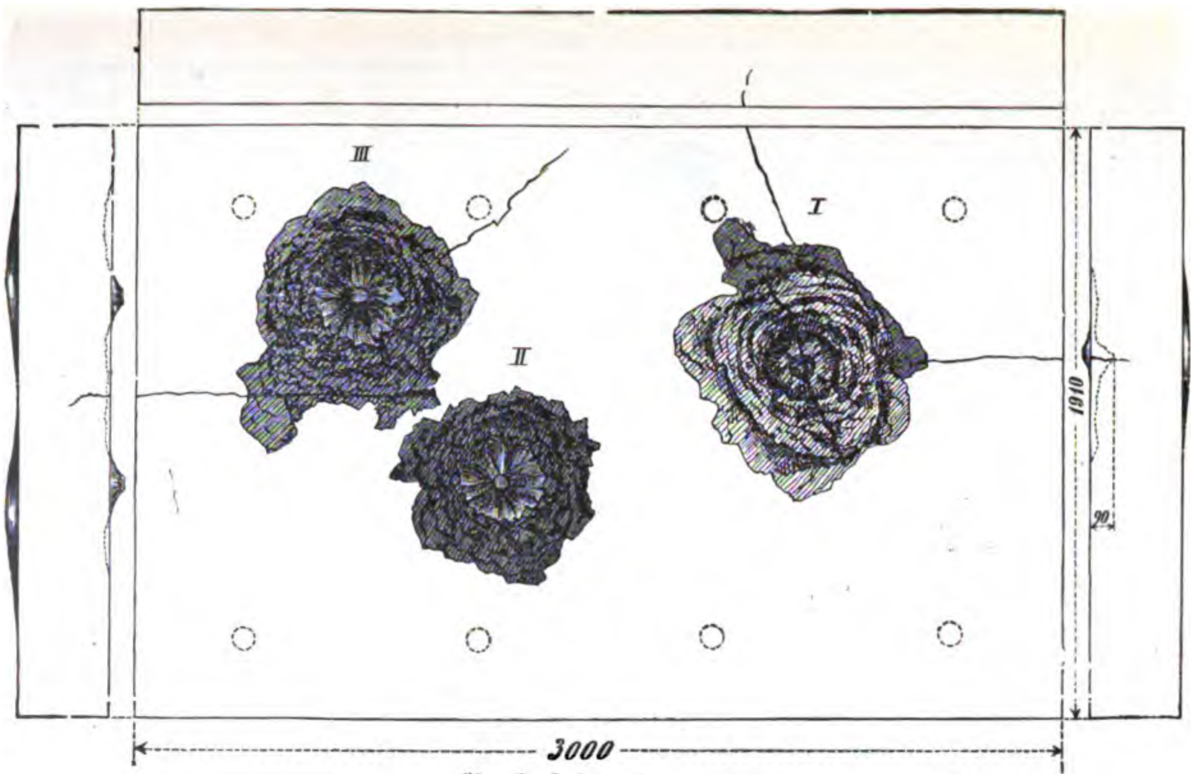
Front face of plate after third shot.

PLATE XIII.



Back of plate after third shot.

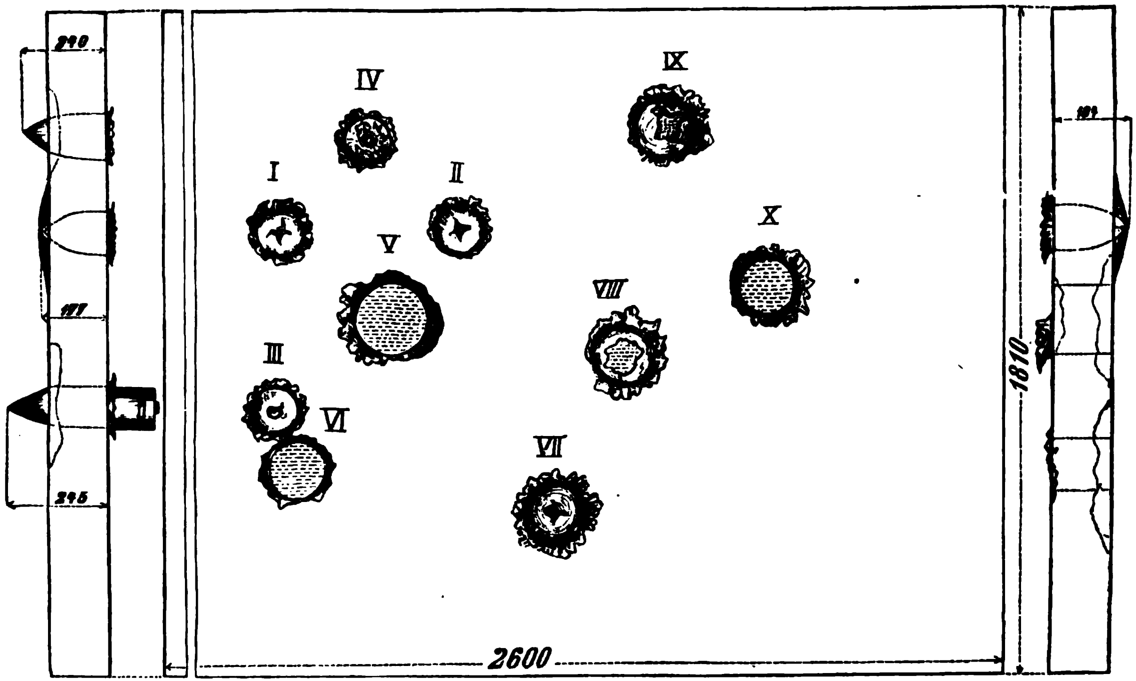
PLATE XIV.



Sketch of plate after test.

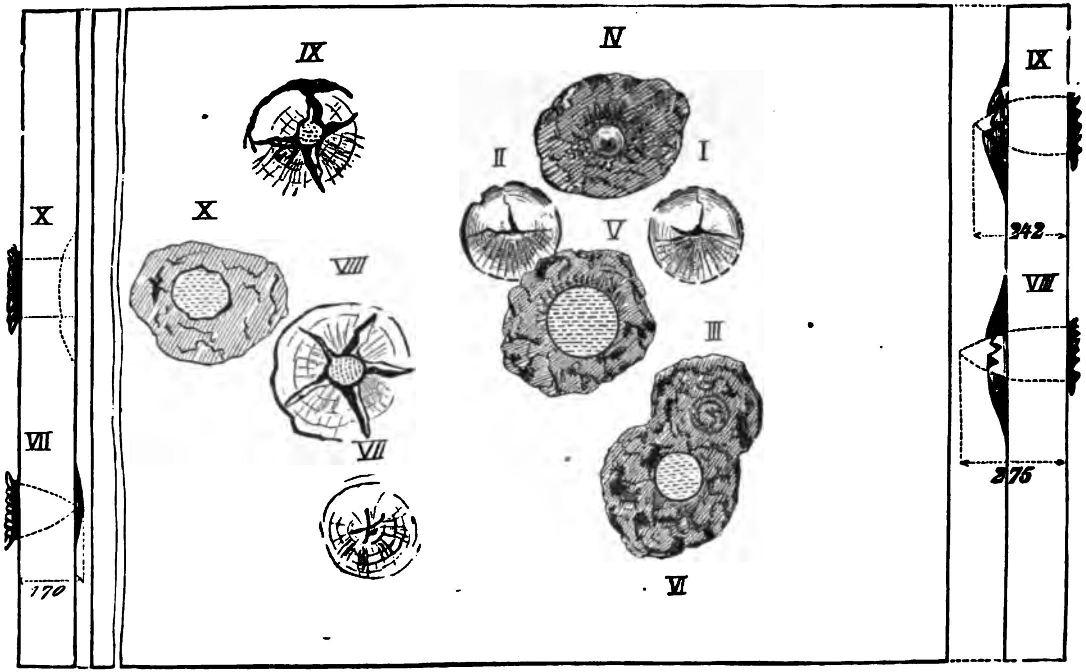
PLATE XV.

Un-hardened *Krupp* nickel steel plate.



Sketch of plate after test.—*Face.*

PLATE XVI.



Sketch of plate after test.—*Back.*

thick, should surpass by 83% in resistance to perforation wrought iron plates of equal thickness, this Krupp plate, 146 mm. thick, has shown a superiority of 84% over an unhardened *steel* plate, and corresponds in resisting power to a wrought iron plate 378 mm. thick. We must also call attention to the fact that although the armor plate was perforated, the target was not, at least by the 15 cm. shell of the second shot; the interior of the ship, whose side, represented by the armored target, was to be protected by the plate, would therefore have remained uninjured. To have produced the effect referred to would have required a much greater energy. The sister plate, 425 B, was not perforated by the 15 cm. shell, in such a way that the latter penetrated into the second layer of backing, until the energy became 987.3 mt., or 122.8 more."

"It is worthy of notice that the 21 cm. shell perforated plate 413 II with an energy which would have sufficed to perforate a soft steel plate 238 mm. thick, so that in this shot it showed a superiority of only 63% over the steel plate. From this it appears that face-hardened plates offer relatively less resistance to projectiles of larger caliber, because their greater total striking energy, as was shown above, exhibits itself in a racking effect. In the second shot (15 cm.) the energy per square centimeter of cross-section of projectile was 4.951 mt., in the fifth shot (21 cm.) it was 3.531 mt.

FACE-HARDENED KRUPP NICKEL-STEEL PLATE NO. 425 B.

Dimensions as in plate 413 II, viz: Thickness, 146 mm.; length, 2.73 m.; height, 1.50 m.; —— weight, 4,760 kg.

Backing and fastenings as in plate 413 II.

Angle of impact of projectiles as in plate 413 II.

No. of shot.	Gun.		Projectile.		Distance of plate from muzzle of gun.	Velocity of projectile at target.	Striking energy of projectile.	Thickness of plate which projectile would perforate.		Depth to which projectile penetrated.	Effect on projectile.
	Cal. cm.	Length.	Kind.	wt. kg.	m.	m.	mt.	Ordinary steel. mm.	Wr'ght iron. mm.	cm.	
I	15	L/30	Steel armor-piercing shell. L/3.4	51	120	475.7	588.2	204.3	284.0	2.2	Broke up.
II	15	L/30	"	51	—	576.2	863.0	269.0	381.9	2.0	"
III	21	L/22	Steel armor-piercing shell. L/2.5	95.7	121	476.0	1105.0	222.0	310.6	10.0	"
IV	21	L/22	"	95.5	—	495.9	1197.0	235.0	330.2	—	"
V	15	L/30	Steel armor-piercing shell. L/3.4	51	120	616.3	987.3	295.8	423.1	—	"

EFFECTS ON THE PLATE.

Shot I.—The plate received an indentation 22 mm. deep, but no cracks; on

the back a bulge 10 mm. high and 200 mm. in diameter, free from cracks. Backing slightly crushed.

Shot II.—Plate not perforated; projectile head crushed in shothole. The material of the plate was flaked off over an area 250 mm. in diameter and 15 mm. deep, and the whole pressed to the rear. On the back a bulge 45 mm. high and 300 mm. in diameter, with a large vertical crack. Backing considerably crushed.

Shot III.—Plate not perforated; the whole pressed back 20 mm.; projectile head crushed in shothole, and fell out at shot V. Depth of penetration, 100 mm.; edge of shothole flaked off to a depth of 20 mm. On the back a bulge 80 mm. high, 500 mm. in diameter, with a large concentric crack. Backing considerably crushed.

Shot IV.—The plate was perforated. The section punched out was held by feathery fibers at the side and hung down. No fragments of the projectile reached the wooden backing.

Shot V.—Plate perforated. The section punched out and fragments of the projectile in the second layer of the backing. Edge of shothole flaked off; shotholes 2 and 3 connected by very fine surface cracks. On the back, shothole broken away below. Backing in both layers of timbers very much crushed. The inner skin showed no signs of any effect of the projectiles.

"The plate showed a resistance of 2.03 :1 as compared with a soft steel plate, and *was accordingly superior in resisting power to Plate* 413 *II.*

"The total energy on 425 B was greater than on 413 II, amounting to 4740.5 mt., or 421.3 mt. more; the energy per ton of plate on 425 B was 995.9 mt., or 52.9 mt. more than on 413 II. The plate resisted the attack *without receiving any cracks.* All the bolts remained uninjured, and therefore the plate would have remained in position on the ship's side and would have continued its protective action farther. But whether the smaller power of resistance of plate 413 II is to be ascribed to the hair-cracks (formed in the hardening process), appears to us very doubtful, because its behavior in the trial furnishes no evidence that they diminished its resistance. Probably the cause lies in the fact that it was prepared by another process, the value of which was to be tested by the trial."

"The trial of plate 425 B again shows that the action of projectiles of large caliber, striking the weaker kinds of plates with energy not sufficient to perforate them, is more efficient in breaking up than in perforating. Be it remarked, in addition, that the plates for catching the fragments of the projectiles were provided with a protective structure of wood, whose timbers were crushed by the fragments to a degree not hitherto observed. Many fragments rebounded 200 m. from the target."

In order to determine whether the new process is as effective in the preparation of thicker plates, as it proved for plates 146 mm. thick, two face-hardened nickel-steel plates 300 mm. thick were manufactured, and tested on the 15th and 16th of March last.

FACE-HARDENED KRUPP NICKEL-STEEL PLATE NO. 432[v].*

Thickness, 300 mm.; length, 2.00 m.; height, 1.80 m.; —— weight, 7,850 kg.——

* This plate, 432[v], was a fragment broken off the next plate, 432[u], which was intended merely to determine the resisting power of the material, by means of a few shots fired for that purpose.

The plate was fastened to the backing by means of nickel-steel bolts 80 mm. thick, screwed into the back of the plate to a depth of 50 mm. The backing consisted of 1 m. thickness of oak (four layers of 25 cm. each, not bolted) and 40 mm. wrought iron inner skin (two sheets of 20 mm. each).

Angle of impact: 90° in case of the 28 cm. shell, 87° in case of the 21 cm. shells.

No. of shot.	Gun.		Projectile.		Distance of plate from muzzle of gun.	Velocity of projectile at target.	Striking energy of projectile.	Thickness of plate which projectile would perforate.		Depth to which projectile penetrated.	Effect on projectile.
	Cal. cm.	Length.	Kind.	wt. kg.	m.	m.	mt.	Ordinary steel. mm.	Wr'ght iron. mm.	cm.	
I	28	L/22	Steel armor-piercing shell. L/2.5	230.6	120	552.5	3588	373.0	543.1	13.4	Broke up.
II	21	L/30	L/3.3	138.4	117	662.6	3097	464.0	687.1	?	"
III	21	L/30	"	138.6	117	682.6	3292	484.6	720.0	?	"

EFFECTS ON THE PLATE.

Shot I.—The head of the projectile remained in the shothole, but fell out at shot II, showing a depth of penetration of 134 mm. The plate was not cracked; on the back a bulge was formed, 450 mm. in diameter and 35 mm. high.

Shot II.—The face of the plate at the point struck was flaked off over a space 450 to 500 mm. in diameter. The plate was not cracked. Bulge on back 450 mm. in diameter and 35 mm. high.

Shot III.—The part struck was flaked off over a space 450 m. wide to a dept of 20 mm. The broken head of the projectile remained sticking to the plate. In the hardened face of the plate there were 2 cracks, one runing down and the other to the left from shothole III, the former penetrating 250 mm. into the plate, the latter only 80 mm.

"The behavior of this plate is *a good proof of the extraordinary toughness of the steel*, if we take into consideration the fact that shot III struck so near the edge of the plate that the center of the shot was only 430 mm. from the left edge, and only 360 mm. from the lower edge. In shothole I, a fine cross-crack was formed, but it had apparently only a slight depth. Moreover, the bulge on the back, which was free from cracks, was no larger than that of shotholes I and II. The plate withstood a force of 9977 mt., or 1271 mt. per ton of plate, without receiving a through crack, and without being preforated (and thus fixing its resisting power); only this was proven, that the 21-cm. cannot perforate this armor at any battle ranges."

FACE-HARDENED KRUPP NICKLE-STEEL PLATE NO. 432[n].

Thickness: 300 mm., length: 3.0 m., height: 1.90 m.——weight. 13485 kg.——

The plate had received in the hardening process a fine crack runing lengthwise on its face to the left (see Figure 14), on its back there were two furrows cut out, 20 mm. deep, 700 mm. long (see Figure 13).

Backing and fastenings of the plate as in plate 432v.
Angle of impact of shots: 81°.

No. of shot.	Gun.		Projectile.		Distance of plate from muzzle of gun.	Velocity of projectile at target.	Striking energy of projectile.	Thickness of plate which projectile would perforate.		Depth to which projectile penetrated.	Effect on projectile.
	Cal. cm.	Length.	Kind.	wt. kg.	m.	m.	mt.	Ordinary steel. mm.	Wr'ght iron mm.	cm.	
I	30.5	L/35	Steel armor-piercing shell. L/2.8	324.8	115	534.3	4726	419.2	615.9	9.0	Broke up.
II	"	"	"	324.5	"	575.7	5482	466.0	690.2	18.0	"
III	"	"	"	323.2	"	607.5	6078	501.8	747.5	?	"

EFFECTS ON THE PLATE.

Shot. I.—Plate not perforated. The hard surface flaked off at the point of impact in large, conchoidal pieces, to a depth of 20 mm. over a space 660 mm. wide. One piece embracing half the shothole (see Figure 11) hung so loosely on the plate that it could be taken off by hand. Over the portion where the plate was flaked off it was covered with melted projectile material and in part welded to it. The point of the projectile stuck in the shothole, but fell out at shot II, so that its penetration could be measured and was found to be 90 mm.

The back received a bulge 500 mm. in diameter and 25 mm. high, without cracks.

"It appears from this result, that the intention was to determine, if possible, the limit of resistance of the plate, for it was to be supposed that it would be reached with the 30.5 cm. gun."

Shot II.—Plate not perforated. On the face a crumbling off to a depth of 40 mm. over an area 600 to 700 mm. in diameter (Figure 12). The head of the projectile, which remained sticking, fell out at shot III, showing a depth of penetration of 180 mm. The hard surface of the walls of the shothole was broken off considerably and welded with projectile steel. The same effect was apparent on the portion of the face of the plate where the surface layer had flaked off. The plate was not cracked, and the bulge on its back 60 mm. high, had no cracks.

Shot III.—Plate not perforated. On the face a flaking off to a depth of 60 mm. over a space 850 mm. in diameter, also covered with fused projectile steel and welded with it. The head of the projectile remained sticking in the shothole. The haircrack under the shothole was somewhat lengthened and deepened, and a fine radial crack appeared in the hardened layer on the face of the plate near the upper edge, besides a fine crack 80 mm. deep passing through shothole I towards the upper edge and one towards the right edge (see Figure 14). In the bulge on the back, 75 mm. high, appeared a slight concentric crack 150 mm. long.

"The plate withstood a force of 16,286 mt., or 1207.7 per ton of plate, without being perforated and without receiving a through crack. *The trial, therefore, neither determined the limit of resistance to perforation nor of endurance of the plate, neither did it determine its maximum power of resistance in any respect, but it showed that the plate possesses great toughness combined with a remarkable degree of hardness. Indeed we may say that with this plate the ideal armor has been reached, its face possessing a degree of hardness, such that all projectiles striking it break up, while its back is sufficiently tough to prevent it from breaking and falling off in pieces from the ship's side.* So far as we know, neither the American nor the English manufacturers have thus for succeeded in producing plates of such resistance to perforation, especially, and that is the point we wish to emphasize, combined with such toughness; their plates of a degree of hardness approaching these invariably broke in pieces."

"It is to be noticed that in this case again the haircrack (due to hardening) in the plate appeared to have no deleterious effect on the resistance of the plate."

"Since face-hardened plates must receive their final form before being hardened, and since in the hardening process changes of form cannot always be avoided, we are compelled, in those cases where special forms are essential, to use plates which are not face-hardened. Of course, such plates must still have as great a power of resistance as possible, otherwise the portions of the ship covered by them might be sought as targets by the enemy's artillery. For the preparation of such plates a method that serves to attain by metallurgical processes the necessary power of resistance, which is ordinarily obtained by carbonization and face-hardening, would find application. Krupp exhibited such plates, made of nickel-steel, in Chicago. The Krupp steel plate used in the comparative trials in Texel, instituted by the Netherlands in August, 1893, was also nickel-steel, prepared without face hardening, as was the St. Chamond plate. The statement by Captain Jacques, and which was accepted by German publications, that the Krupp plate was also harveyed, should therefore be corrected. The Krupp plate in Texel, 150 mm. thick, was perforated by the 12 cm. shell with 500 m. velocity of impact, the St. Chamond plate with 573 m. From this it appears that in the Krupp works improvements in the preparation of so-called *soft* nickel-steel plates, not hardened in water, but tempered in oil, have been quite as great as those in the production of face-hardened plates."

How great these improvements have been is evident from the trial of such an *unhardened nickel-steel plate*, which took place on the 14th of July and the 15th of December, 1894, on the firing grounds at Meppen:

UNHARDENED KRUPP 155 MM. NICKEL-STEEL PLATE.

Thickness: 155 mm., length: 2.6 m., height: 1.81 m., weight: 5390 kg.

The plate was fastened on a backing of 60 cm. of oak.

Distance of plate from muzzle of gun: 117 to 120 m.

Angle of impact of projectiles: 87° and 90°.

"The plate withstood a total energy of 5109.9 mt. without any signs of a crack."

"The fact that the 12-cm. shells broke up into many pieces, during the firing of the 14th of July, left no doubt that with the great strength of the plate and the high velocities of the projectile the 12-cm. shell was over-taxed, therefore, to continue the trial, a gun of larger caliber was deemed more appropriate. Hence, between shot IV and VI (12-cm.) a 17-cm. was inserted.

No. of shot.	Gun. Cal. cm.	Gun. Length.	Projectile. Kind.	Projectile. wt. kg.	Velocity of projectile at target. m.	Striking energy of projectile. mt.	Thickness of plate which the projectile would perforate. Ordinary steel. mm.	Thickness of plate which the projectile would perforate. Wr'ght iron. mm.	Depth of penetration of projectile. cm.	Effect on projectile.
I	12	L/35	Steel armor-piercing shell. L/3.3	26	500.2	331.6	170.7	234.0	17.7	Remained entire, but was set up 9 mm.
II	"	"	"	"	515.1	351.6	178.0	244.8	18.4	Entire, set up 11 mm.
III	"	"	"	"	577.2	441.5	209.5	291.7	24.5	Broken.
IV	"	"	"	"	594.6	468.5	218.5	305.4	24.0	Broken.
V	17	L/40	"	77	429.0	722.3	206.3	287.0	Thro'	Uninjured, set up 2 mm.
VI	12	L/35	"	26	654.8	568.2	250.8	354.2	Thro'	Lodged uninjured in the backing.
VII	15	L/30	Steel armor-piercing shell. L/3.4	51	407.8	432.3	164.0	224.1	17.0	Not broken; set up 20.5 mm.
VIII	"	"	"	"	462.0	554.8	196.0	271.5	27.5	
IX	"	"	"	"	477.4	592.4	205.4	285.6	24.2	
X	"	"	"	"	498.8	646.7	218.6	305.5	Thro'	

The projectile struck the target with a velocity of 429 m. and 722.3 mt. (3.087 mt. to the square centimeter of cross-section), perforated it completely and penetrated 9 m. beyond, 1 m. deep into the ground; it was uninjured, but was set up 0.3 mm. in the cylindrical part, 2 mm. in length. From this it appeared that the 17-cm. gun was unnecessarily large, hence the trial on the 15th of December, 1894, was continued with the 15-cm. gun, the velocity of impact being gradually increased. The penetration of the separate shots may be seen in Figures 15 and 16. The last shot perforated the plate, the projectile penetrated 825 mm. and lodged in the backing. With a velocity of impact of 498.8 m. it would have perforated an iron plate 302 mm. thick, or a steel plate 217 mm. thick. The four 15-cm. shells were not broken up, but were set up in the cylindrical part so as to produce as much as 20.5 mm. shortening, and the point of the projectile was pressed aside 20 mm. out of the axial line. The last shell had, besides, a cross crack, somewhat broken out, in rear of the head. It perforated the plate with 3.704 mt. of energy to the square centimeter, the 12-cm. shell in shot VI perforated it with 5.024 mt."

"All the shotholes had the well-known fringed border, indicating a homogenious and tough steel. There is no doubt that the Krupp Works have succeeded in casting the steel ingots for their armor plates free from blowholes, without being compelled to loose anything in toughness, as was at first

feared would be the case; on the contrary, it appears that the increase in the resisting power of the unhardened nickel-steel plates on account of increased hardness is combined with a corresponding increase in toughness."

—*Stahl und Eisen*, Sep. 1, and 15, 1895.

c. Powder and Explosives.

Cordite.

Cordite is an intimate mixture of nitro-glycerine, gun-cotton, and mineral jelly, or vaseline. The thorough blending of the two main ingredients is promoted by the addition of acetone, a substance in which both are soluble, during the process of incorporation. The mineral jelly acts merely in the way of restraining the violence of explosion, and serves also to produce a little smoke, which acts usefully as a lubricant to the bore of the gun. The curious effect of the intimate mixture of nitro-glycerine and gun-cotton is to modify their characters and properties altogether. The former substance is an unstable liquid, which decomposes with explosive force on account of the mobility of its molecules; while dry gun-cotton behaves in the same manner because of its highly porous nature, which permits ignition to take place almost simultaneously throughout its mass. Cordite, on the other hand, is a horny substance, which burns only on the surface even under the severe heat and pressure obtaining in guns, as is demonstrated by the fact that partially consumed cords, blown out of guns, retain their shape though reduced often to extreme tenuity. The consequence of this property is that the rate of explosion can be regulated by varying the proportions of surface to volume; thus cords of smallest diameter burn more quickly than the larger sizes, and by slicing up the material into very thin discs, and omitting the vaseline, explosion, having almost the rapidity of detonation, can be produced. It thus becomes easy to adapt cordite to any nature of gun. The service pistol, for example, takes cords of .01-inch diameter, cut to short lengths, forming, in fact, a fine powder; while the new 12-inch wire gun takes bundles of cords ½-inch in diameter and 14 inches long.

Like nitro-glycerine and gun-cotton, cordite is sensitive to heat and light. Exhaustive experiments have shown that it is not expedient to expose it constantly to a higher temperature than 100 deg. Fah., although it suffers no change if occasionally heated as high as 130 deg. Fah. Long exposure to temperatures above 100 deg. Fah. leads, however, to no danger, but may occasion a very slow decomposition of the material, an effect which will show itself in the ballistics obtained from the guns it is fired from; but no change of this nature has as yet been actually observed. The finer the subdivision of the explosive, the more susceptible it naturally is to heat.

Experiments carried on during a whole winter in Quebec have demonstrated that the ballistics are not affected by extreme cold; but experience, even in this country shows that cordite transferred suddenly from a very cold room into a warm one, will occasionally extrude a minute portion of its nitro-glycerine, which appears as a very light dew upon its surface. But this exudation is gradually reabsorbed as the material gets warm; and in any case it is not a source of danger, nor does it affect the shooting qualities of the material.

Prolonged trials in India have also demonstrated that cordite does not suffer from exposure to the extreme temperatures of a tropical climate, and as magazines can always be arranged not to have a temperature higher than 100 deg. Fah., there seems to be no reason why large quantities should not be

stored for a considerable number of years. The occasional exposure to much higher temperatures in the pouches of the soldiers, and the limber boxes of the guns, does not produce any deleterious effect. Direct sunlight quickly turns cordite into a very dark-colored substance, and diffused light has the same effect only after very much longer exposure. Direct light causes slow decomposition: but sticks exposed for several years to diffused light, though very much darkened in color, show no measurable chemical change. Owing to the total absence of dust, cordite is a remarkably safe explosive to manipulate. It can be exploded by a severe blow, as, for instance, by striking with a hammer a cord laid on an anvil; in such case the portion immediately under the hammer explodes, but the explosion is not communicated to the cord on both sides of the hammer.

When fired in the open, or even when enclosed in the 100 pound service cases, it only burns with a fierce flame even when in considerable masses. Thus, a bonfire made round eight cases piled up against each other only fired the contents of the boxes in succession as the wood of the boxes burned away, and not only was there no expulsion, but the lids of the boxes were merely forced open enough to let the products of combustion escape. Again, a temporary magazine in which two tons of cordite were distributed on reticulated shelves was kept at 100 deg. Fah. a fortnight and then fired. There was no explosion. The slate roof was lifted off by the rush of gas and deposited on the ground beside the building, no more injured than would be accounted for by its fall; the windows in the brick gables were not broken, and the door had to be unlocked to give access to the firemen.

There is, indeed, some difficulty in igniting cordite even when it forms the charge of a gun, and primings of gun-cotton or black powder have to be used in the case of cannon, while in small arms the percussion caps have to be charged with composition which will give a good flash. When, however, the priming is sufficient, misfires and hangfires are rare.

The volume of the chamber of a gun compared with the weight of the charge is a matter of great importance. On account of the relatively large volume of gases given out and their high temperature, compared with the products of combustion of black powder, the density of the charge must be much less. Solid cordite measures 17¾ cubic inches to the pound, and if fired in a chamber of that capacity would give a pressure of at least 120 tons to the square inch, which would, of course, be destructive to any gun. If a density of 54 cubic inches be assigned, as is the case in some of the larger quick-firing guns, a pressure of 40 tons to the inch might be realized, and is nearly the maximum which can be obtained with black powder; whereas, if, say, 100 cubic inches to the pound be the density, as is the case in many guns, the pressure can never rise above 20 tons to the inch; consequently it is found that in guns with high density charges the pressure and velocities are much affected by climatic changes, and by conditions of the bore and of the shot. But even under such unfavorable conditions of density, the regularity of shooting is quite equal to that obtained with black powder.

The diameter of the cords is proportioned to suit the bore of the gun, the capacity of the chamber, and the length of travel of the shot. Up to the present the sizes made range from .01-inch diameter for the service revolver to .5-inch diameter for the new 12-inch naval gun.

With respect to erosion, it may be said that it certainly is not greater than that arising from the use of black powder, and it is of a much more favorable

kind. Black and brown powders scoop out and plough rough, irregular channels in the bore, whereas cordite appears to wash away the surface in a uniform manner. This effect is probably due to the absence of solid or liquid particles in the products of combustion, and to the presence of a large proportion of carbonic oxide at a high temperature. The erosion extends for only a few calibres along the bore, and owing to these circumstances expanding gas checks on the driving bands of the shot enable the gun to shoot well longer than when powder is used. It should be borne in mind also that the ballistics obtained by the use of cordite are very much higher, as a rule, than with black powder; in the case of the 12-inch naval gun, for example, the energy imparted to the shot is 1.8 times greater than in the old service gun, consequently increased wear must be expected.

The manufacture of cordite is extremely simple. The nitro-glycerine and the dried gun-cotton are mixed together in accurately weighed proportions. The liquid is poured over the gun-cotton, and mixed with it by hand till the nitro-glycerine is completely absorbed, and the resulting mass looks like a quantity of dirty white moist sugar. This mass is then placed into kneading machines with a proper proportion of acetone, and is incorporated for three and a-half hours, when about 5 per cent of vaseline is added, and the kneading continued for another three and a-half hours. The mass then becomes a stiff dough, not unlike raw Jamaica sugar in appearance, and about the same color, and is ready for squirting into any size or form that may be needed, for unlike the old powders, the composition of cordite is the same in every variety of size produced.

The squirting machines consist simply of vertical cylinders of various sizes, into which the dough is placed. They are fitted at their lower ends with one or more removable dies, and provided with pistons actuated by screws or by hydraulic cylinders. In the former case the pressure of the screw is transmitted through a hydraulic cushion which gives the means of noting the pressure and also of relieving it when excessive. For the small sizes used in rifle ammunition, the cords are wound automatically as they issue from the dies on to reels holding about one pound each, these are blended together in tens on to a single reel, and six of the latter are combined on one reel, from which the sixty strands are fed into the cartridges. The larger sizes are either wound by hand on to reels, whence they are cut off in lengths, or they are delivered by the press on to an endless band to which knives are fastened at the required distances. The cord lies over the knives, which passing under a small roller cut through the cord, and leave it ready to be picked off by boys, and arranged in shallow trays. The small-arm reels and the trays of cut cord are placed in stoves, in which they are dried by exposure to currents of air warmed up to 100 deg. Fah., and in this process all the acetone is driven off. When dry the cut cords, like the cordite on reels, is blended so as to make uniform samples.

The danger of the manufacture is confined to the production of the nitro-glycerine and the drying of the gun-cotton. As soon as the two explosives are mixed together they appear to be incapable of explosion, except when confined in a gun. At Waltham Abbey, some years ago, a gun-cotton drying stove caught fire, from some cause which has never been ascertained, as there was no one near it at the time. The material was perfectly dry, for the stove was just going to be emptied, yet there was no explosion and no one was

hurt; the fire was, however, exceedingly fierce, and any one in the stove would certainly have been destroyed. The accidental explosion of a large quantity of nitro-glycerine, though attended with lamentable loss of life, also showed that the damage done was very local, apparently much more so than the destruction which a corresponding quantity of black powder would have produced. We have very little doubt but that fuller experience will show that our War Department has made a wise selection in adopting cordite as the explosive best suited for our guns.

—*The Engineer*, March 13, 1896.

MILITARY GEOGRAPHY.

Cuba.

For nearly a year Spain has been engaged in a war with Cuba, which by degrees has acquired an extremely grave character. The object of the war on the part of Spain, is the suppression of an insurrection of part of the population, whose motto is "Free Cuba."

The movement began in one of the provinces in the latter part of February, 1895, and has gradually spread over the whole island, giving rise to fears in the Peninsula that Cuba may succeed in breaking loose from the mother country, and that Spain may thus lose Cuba, which with the Phillipines, is the last remnant of her once vast colonial empire. Public opinion stirred up by this consideration has forced the government to send out reinforcement after reinforcement to the Antilles, so that the total of these now exceed 100,000 men. To accomplish this, the government has employed the best of its generals and officers, and has been compelled to disband in part its continental army so that the most of these regiments are now reduced to single battalions; it has likewise been forced to call out one class of reservists to anticipate the enrollment of the class of 1895, and to send off hurriedly to the seat of war many raw recruits. The ship yards of Cadiz and some in foreign countries have been kept busy building warships for coast duty.

Notwithstanding the dispatching of so many men and so much material, the situation seems in no way to improve, and it is difficult to predict when this ruinous expedition will end.

The events of the war are as yet known only through Spanish official reports, and the accounts published by the insurgents in American newspapers. Since these directly contradict each other, it is difficult for us to construct from them a clear narrative of the campaign; and they are equally useless for forming a judgment upon the conduct of operations, since they are totally deficient in the necessary data.

We are so accustomed to seeing Cuba on maps of small scale, that it is difficult for us to conceive correctly its real magnitude. A few figures may fix our ideas on this subject. From Cape Maisi at the eastern end of the island to Cape Antonio at the western extremity, the distance is 1450 kilometers (900 miles), not taking into account the general curvature of the coast line. This is almost the distance from Paris to Madrid. The mean breadth of the island is about 100 kilometers (60 miles); at some places the distance from the north to the south coast line is not more than 60 kilometers (37 miles).

Geographers have often compared the form of Cuba to that of a bird's tongue. The base would be the coast line from Cape Maisi to Cape Cruz, extending in an east and west direction. West from Santiago de Cuba it is skirted by a chain of mountains known as the Sierra Maestra and the Sierra

d'El Cobre, which have peaks reaching an altitude of 18co meters (5900 feet). There are besides several other clumps or groups of mountains in the island, of more or less importance, which never exceed in altitude from 600 to 800 meters (2000 to 2600 feet). These are situated between Santiago de Cuba, Mayari and Cape Maisi; to the north of d'Holguin; between Moron and Remedios; between Cienfuegos and Santi Spiritus; to the south of Matanzas, and finally along the north coast between Havana and Cape San Antonio. All these groups are separated from each other by broad valleys, which sometimes run from one coast to the other.

The rivers are numerous and some of them are navigable in part, but due to the form of the island their course is short. The Rio Canto, which empties into the Sea of the Antilles after a course of 212 kilometers (132 miles) is an exception to this rule.

The coast line which is marshy here and there, is bordered by lines of coral reefs and keys, dangerous to cross, but affording good shelter within.

The population is both white and colored; the former are Spaniards or creoles, the latter negroes or mulattos. The exact number of the population is not known; nevertheless the following estimate by province is probably very close:

La Havane	480,000
Santa Clara	360,000
Matanzas	300,000
Santiago de Cuba	230,000
Pinar del Rio	220,000
Puerto Principe	172,000
Total	1,762,000

Of this total it is estimated that 420,000 are negroes. There are besides some 40,000 Chinese scattered through the island, who to some extent took the place of the negroes as laborers, when slavery was finally abolished in 1880.

The control of the island is in the hands of a governor general who has the title of a captain-general. He is assisted by a Junta, named by the Spanish government, but their duty is merely advisory.

The island is divided into six provinces as follows, going from east to west: Santiago de Cuba, Puerto Principe or Camaguey, Santa Clara or Cinco Villas, Matanzas, La Havane and Pinar del Rio or Vuelta de Abajo. Sometimes in common parlance the old divisions are still retained,—the eastern department, the central department and the western department. The first corresponds to the province of Santiago; the second to the provinces of Puerto Principe and Santa Clara; the third to those of Matanzas, of La Havana and of Pinar del Rio.

The affairs of each province are administered by a civil governor and a provincial deputation. In each city is a municipal council presided over by an alcaide or mayor, appointed by the general governor. Among the most important cities are Havana, the capital, with 200,000 inhabitants; then, in the order of their importance, Santiago de Cuba, 59,000; Matanzas, 56,000; Cienfuegos, 40,000; Puerto Principe, 40,000; Manzanillo, 34,000; Santa Clara, 32,000; Holguin, 32,000.

The island of Cuba has had representatives in the Cortès since 1880. It sends fourteen members to the Senate and thirty delegates to the House of Representatives (one for 40,000 population). To be an elector it is necessary to pay a tax of 125 fr. ($25.00) per year.

The budget is voted at Madrid. The estimates for the year 1894-5 we
follows:

Receipts.

	Pesetas.
Taxes and imports	35,247,500
Custom house duties	59,450,000
Stamps, registration, mail service	10,873,295
Lottery	15,520,000
Revenue from state property	1,995,000
Incidental receipts	690,000
Total	123,775,795
[or about $24,000,000]	

Expenses.

Public debt	62,891,675
Justice and religion	4,978,465
War	29,483,700
Navy	5,275,680
Finance	3,810,625
Interior	20,180,440
Instruction and public works	3,855,625
Total	130,476,210
[or about $25,300,000]	

There is therefore for this year an initial deficit of 6,700,415 pesetas. T
deficit for 1893-94 was 28,152,000 pesetas. As this has been going on regula
for some years, the debt of the island is constantly on the increase.

Spain keeps an army and a naval division in Cuba, paid from the budget
the island.

The army on its peace footing is composed as follows:

Infantry.—Seven regiments and two battalions of four companies. O
battalion of chasseurs of four companies. Twelve companies of mount
light troops. The squadron of Santa Catalina de Guaso. One section
orderlies. One discipline brigade.

Cavalry.—Two regiments of four squadrons each. One squadron of Cam
juani volunteers.

Artillery.—One battalion of position artillery of six companies each. On
mountain battery. One company of workmen.

Engineers.—One battalion of four companies.

Auxiliary service.—Sanitary brigade. Administration troops.

The effective force allowed by the budget for these different arms is 67
officers and 13,843 men. Under the orders of the governor are also the civ
guard (gendarmerie) comprising 191 officers and 4400 guards, of whom 113
are mounted and the "corps of public order," counting 25 officers and 97
men; in all about 20,000 men.

Besides these regular troops recruited in Spain, there exist in Cuba voluntary bodies of the different arms. These are local militia who serve without pay and number about 60,000 men. These volunteers furnish their own clothing and equipment; their arms are furnished them by the state when they are called out and consist of rifles of old models. Each city and town has its organized units of volunteers; their number according to the annual of 1895 is as follows:

Infantry: 37 battalions, 132 companies, 64 sections.
Cavalry: 12 regiments, 35 squadrons, 17 sections.
Artillery: 1 battalion, 5 companies, 1 field brigade.
Engineers: 1 battalion, 3 companies.

The naval division in peace consists of four cruisers, one torpedo cruiser, two gunboats of the first class and four of the second. There is also attached to the fleet a company of marines. There is àn arsenal at Havana.

Cuba is situated entirely in the tropical zone with its shores bathed by the Gulf Stream. Heat and humidity are therefore the characteristic features of the climate, and thanks to their influence, the pearl of the Antilles possesses remarkable fertility. There are two principal seasons; the dry season, lasting from December till May, and the rainy season, which begins in June and ends in November.

In the dry season the temperature is never high, and on some days will fall as low as nine degrees above zero (centigrade), and even lower in the mountain regions in the east. This is the favorable period for military operations.

With the rainy season hot weather comes. From its commencement vegetation grows in a wonderful manner; shrubs and vines of all kinds shoot up so vigorously, that in a few weeks large tracts are covered by impenetrable brakes and thickets, called the "manigua." The yellow fever also comes at this time and is especially trying to Europeans. These conditions render the operation of tooops extremely difficult, if not altogether impossible, during the entire season.

The richness of Cuba lies in its vegetable productions, sugar cane, tobacco, coffee, oranges and bananas; and also in its ores. The resources of the provinces are very unequal, and consequently the development of the roads differs markedly.

The province of Santiago de Cuba, mountainous and wooded, is especially rich in mines; the sugar cane is but little cultivated and there exist but few tobacco plantations, and these are located on the northern slope of the Sierra Maestra. There are very few roads in this part of the island, and but three short sections of railroads,—from El Cobre to San Luis, from San Luis to Santiago de Cuba, and another from Santa Catalina to the port of Guantanamo.

The province of Puerto Principe, less hilly than the preceding, is likewise covered with numerous forests; it is here especially that we find the "manigua." The inhabitants are chiefly occupied in raising horned cattle and horses. As in the province of Santiago, so here there are practically no roads; one railroad puts Puerto Principe, situated in the interior, in communication with the port of Nuevitas, on the north coast.

The provinces of Santa Clara, of Matanzas and of La Havane, are devoted mainly to the cultivation of the sugar cane. There are a good many manufacturies here, which have led to the construction of numerous railroad lines of considerable total length, but rather complicated in their directions, since they have grown up in response to industrial needs. This is the portion of the island where its wealth chiefly lies.

The province of Pinar del Rio also has some sugar refineries, but the principal product is tobacco.

The following figures show the relative importance of the cultivation of sugar cane in the different provinces:

	Refineries.
Province of Pinar del Rio	30
Province of la Havane	40
Province of Matanzas	118
Province of Santa Clara	134
Province of Puerto Principe	6
Province of Santiago de Cuba	39
Total	367

The foreign commerce of Cuba for 1894 amounted to 1,062,804,320 francs; of which 483,411,895 francs were imports and 579,392,425 francs exports.

The imports came principally from Spain, United States, the English Antilles, England and France.

Two-thirds of the exports go to the United States, the rest to Spain and the different countries of Europe.

—*Revue Militaire de l'Etranger*, February, 1896.
[Trans. G. B.]

GENERAL MILITARY MATTERS.

Cyclist Duty in the French Army.

The new regulations for the organization and service of bicyclists in the French army of April, 1895, specify the duties of military bicyclists as follows: first and foremost is the establishment of communication between the staffs, bodies of troops and establishments of the operating army; of minor importance is their employment either singly or in small groups as reconnoissance detachments, or finally, in forced marches as messenger detachments.

On the march, therefore, their duties are mainly keeping up communication between the parts of the advance guard, flanking columns and other troops of security, and between these and the main column; while *at rest* they secure the connection of the cantonments one with another, as well as the parts of the outposts, and of both with the main body; and *in battle* they serve to keep up the communication between the staffs (or headquarters) and to preserve the communications to the rear.

In the larger posts, in which the strength of the garrison, the scope of the duty required and the extent of the distances to be covered, render it desirable, a permanent messenger service of military cyclists may be established even in time of peace. The same holds true for fortified places in time of war.

The force of cyclists to which each staff, body of troops, or military establishment is entitled, may be determined from the following table:

Corps Headquarters.

Corps staff	8.	Medical Department	1.
Chief of artillery of corps	2.	Post Office and Pay Department	3.
Chief of engineers of corps	1.	Telegraph section, 1st line	2.
Intendance	2.		

Division Headquarters.

Division Staff	4.	Medical Department	1.
Artillery Staff	2.	Post Office and Pay Department	2.
Intendance	2.		

Division Headquarters (Independent Division).

Division Staff . . . . 4.	Cavalry Regiment . . . . 2.
Artillery Commander . . . . . 1.	Commandant in Corps Artillery . 2.
Sub-Intendant . . . . 1.	Staff of Artillery Parks . . . . . 2.
Post Office and Pay Department 1.	Corps Ambulance . . . . 1.
Infantry Brigade Staff . . . . . 2.	Division Ambulance . . . . . . 1.
Cavalry Brigade Staff . . . . . 2.	Division Ambulance of a Cavalry Division . . . . 1.
Infantry Regiment . . . . 4.	Field Bakery . . . . 1.
Battalion of Jägers . . . . 3.	
Engineer Company of Division . 1.	

The supply of military cyclists is kept up by the corps commanders, selection being made from among the men having a cyclist certificate to replace men going out.

The cyclist certificate can be obtained by passing an examination before a military commission.

The examinations are held once a year (as a rule) and are ordered by the corps commander; men in their last year of service in the active army have the preference in these examinations, then come those of the reserve and the territorial army.

A minimum requirement (among other requirements) is the covering of a distance of 60 km. (37½ miles) in moderately rolling country, in six hours.

The uniform for all military cyclists is the same. The ornament common to all is a bicycle of cloth (of gold for the non-commissioned officers) on the collar. The staffs, sub-divisions, etc., to which they belong are indicated by various colored insignia, as well as by numerals, partly Arabic and partly Roman, on their caps. Their arm is the cavalry carbine, M. 1890, with eighteen rounds of ammunition.

The wheels are furnished by the state, partly free of cost, partly at the expense of the troops. Of the former each regiment of infantry, engineers and artillery receive two, each independent battalion (with the exception of the African light infantry) two, each cavalry regiment and train squadron one.

The other wheels are obtained by the men by purchase at the artillery establishments, and charged to *harness and hardware;* these wheels officers may obtain for use by the payment of nine francs; the receipts go to the credit of the account of *harness and hardware* for the troops.

In case the number of wheels thus made available is not sufficient, those men having a cyclist certificate are required, when called in, to bring their own wheels with them, for which they receive a certain sum to their credit.

[R.]

—*Mittheilungen über Gegenstände des Artillerie-und Genie-Wesens.*

BOOK NOTICES.

Attaque et Défense des Places, par le major d'état major Librecht et le lieutenant adjoint d'etat-major Cabra. Bruxelles, 1895.

In a work of one hundred and sixty pages, the authors have very thoroughly set forth the manner of putting a place in a defensive condition and that of attacking it. The rôle of fortified places is briefly considered. They are treated as secondary objectives to be attacked only when they can not be neglected: hence they should be so located that an enemy may not be satisfied with either masking or observing them. When they should be besieged is fully stated. Their value is not so much in their conservative details as in their offensive properties and their influence on the enemy's operations. Well placed and distributed, they arrest offensive movements and permit the organization of new means of defense.

The different methods of attack have familiar names except what may be called the *sharp attack*, advocated by General von Sauer, resembling somewhat closely the unprepared attack, but differing from it by requiring the joint action of field forces and a part of the heavy artillery trains. Like the other methods it is described in detail, but it is of recent origin (1885), and its value is not as yet generally accepted. Its success is deemed probable with barrier places, old forts and modern works either too feebly, or else incompletely defended.

Austria, France, Germany and Russia have siege artillery trains, which, while heavy, are still light enough to accompany armies in the field, and include 6-inch howitzers and 8-inch mortars: all available for the sharp or other methods of hastened attack.

Illustrations of an elementary character, such as plans of batteries, profiles, etc., of saps are not given. In fact but two plates accompany the text, and these relate to the disposition of men and materials and locations of works, in connection with the investment of a place and the attack of one of its works. But the text is replete with details: for example, the defense of a place is considered with respect to the garrison and its distribution and duties, the armament, supplies of ammunition, equipage and provisions, depots, magazines, foraging, organizations for extinguishing fire, feeding inhabitants, and sanitary service.

The question occurs what is there that is new? The electric light is no longer in this category; but we may include electric indicators calling for the light to be directed on specified sectors. Telegraph and telephone are somewhat modern; but more so are civil cyclists and military wheelsmen on patrol, outpost and messenger duties. Rifled mortar fire as a defense against siege works, is given the weight due to an accuracy which enables the 6-inch mortar to place fifty per cent. of its projectiles in a rectangle seven feet by twenty-one feet at a distance of eleven hundred yards.

The influence of smokeless powder in sieges is discussed. No advantage is thought to be derived from it by Infantry since the engagements of this arm will be more especially during the night; counter approaches, however, may be the more numerous, since the screens occupied are not made evident

by smoke. The absence of smoke will enable the defense to gain greater accuracy of fire for the guns of the main works and will conceal the location of intermediate, covered works: but it also prevents the discovery of the position of attacking batteries, in at least their first positions. The conclusion reached is—that the attack will possibly derive advantage at first; but in the decisive struggle the defense will profit, and hence in the siege will gain the greater advantage from the use of this form of powder.

Not the least interesting reading is the discussion of the question« Is a bombardment contrary to the law of nations? It is held a fault to bombard places in a country to be conquered since a war of revenge may be developed; or to bombard a large city like Paris since no gain follows when all points of refuge can not be reached: but the force of this last assertion is weakened by the dictum that a bombardment is justified if, when directing his fire against the built-up section, the besieger has good reason to believe that he will hasten the surrender.

One case is said to be contrary to the law of nations—to shell an open city either in retaliation, or to enforce the payment of a war contribution. Is it possible that an enemy's fleet would abstain from thus enforcing a requisition made upon some city situated upon an undefended harbor? If it did not abstain what punishment would follow this departure from usage?

It is not uncommon to decry the use of a technical military book without regard to its merit, because of its foreign authorship; but the rules governing the attack and defense of places are essentially empirical, and who so qualified to write of these operations as those who have taken part in them or who have learned from masters of these forms of warfare, while the fields of operation have been of easy access?

Modern military art requires much devotion to numerous branches of science: it is therefore the more necessary to be careful in the selection of scientific books to which time is to be devoted, in order that we may be saved much of the time which devotees to special branches have expended in preparing treatises thereon. Not many things but much, must be the guiding rule.

Untrammelled by the senseless prejudice against foreign authors and having due regard to the value of time, the student of attack and defense of places, having acquired the details of the construction of siege works, would do well to study the work now under review. Should he then desire to see how close are theory and practice, let him read Thiers and Le Laurencie's "La Defense de Belfort." If time will permit the study of but one of these works, let him however take the last.

J. G. D. K.

A Text Book on the Mechanics of Materials and of Beams, Columns and Shafts. Sixth Edition, Enlarged—Merriman.—Published by John Wiley and Sons, New York.

The high reputation of Mansfield Merriman, Professor of Civil Engineering in Lehigh University, is a sufficient guarantee of the merit of any text book which bears his name as the author.

This text illustrates the advantages which an instructor possesses who is in daily contact with the pupil in the class room and in addition has an intimate practical knowledge of the course to be taught.

The theory of elasticity is very clearly set forth; a correct understanding

of its principles is the necessary basis for a thorough knowledge of the mechanics of materials.

In the latest edition of the work before us new chapters treat of The Strength of Materials, The Resilience of Materials, Tension and Compression, Flexure of Beams, Shear and Torsion, Apparent Stresses and True Stresses, Stresses in Guns, and Plates, Spheres and Columns. Chapter XIV, Stresses in Guns, containing 117 pages, is of special interest and value to the artillerist since it gives a demonstration of the principles which apply to modern gun construction. The formulæ of Lamé, of Clavanino, and of Captain Birnie's modification of Clavanino are deduced. Captain Birnie's formulæ are now used by the Ordinance Departments both of our Army and Navy.

All the subjects in the text have copious examples and problems which illustrate and fix in the minds of the pupils the principles and methods of investigation. In fact, in no text-book known to the writer are theory and practice so happily combined.

J. P. S.

Kriegführung. Kurze Lehre ihrer wichtigsten Grundsätze und Formen. von Colmar, Freiherr von der Goltz.—R. v. Decker's verlag, Berlin, 1895. Pp. 204. $1.00.

The title of this little work may be rendered into English thus:

The Conduct of War, an outline of its most important principles and methods.

Its author is a well-known Lieutenant-General of the German army, the author of several important works, the best known of which is "The Nation in Arms." He is one of the foremost of German military writers, and consequently his name carries the weight of authority. He writes forcibly, and has the faculty of making the dry subjects of theory in the domain of war interesting reading matter for the general reader.

The subject-matter is derived from the lectures of the author delivered at the General Staff School in Constantinople, and comprises the general nature of war, especially that of modern wars, the principal methods of conducting war, the characteristics of the offensive and defensive, and finally the various kinds of strategical and tactical operations.

The work is so rich in interesting material that it is difficult to select any particular part as typical of the whole, therefore we have given in the body of this number a translation of a portion, complete in itself, and will merely call attention to the most valuable points in the remainder, comprising the following sections: 8. The Operations. 9. Strategical Offensive Operations. 10. Tactical Offensive Operations. 11. Strategical Defensive Operations. 12. Tactical Defensive Operations. 13. Operations Under Special Circumstances. 14. Influence of Operations at Sea on the Conduct of War.

On page 81 is a most valuable discussion on the importance of field railroads and their probable effect in future wars. The author is of opinion that the technical troops (railroad regiment) will be far less useful than civilians trained to large railway constructions, to be called into service in time of war.

On page 100 we have an exposition of the essential points of difference between the strategical operations of Napoleon, Frederick the Great and Moltke. Very interesting, too, are his remarks on fortifications and their use in strategy.

The work has already been translated into French (Westhausser, 4 rue de Lille, Paris), and the right of translation has been purchased in England.

It is replete with interest from beginning to end, instructive in the highest

degree, and constitutes the most valuabe contribution to the subject that has appeared in our time.

J. P. W.

A Treatise on Hydraulics. By Henry T. Barry, M. I. C. E., L. L. D., F. R. S. C., Professor of Civil Engineering and Applied Mechanics, McGill University, Montreal. John Wiley and Sons, New York.

From the standpoint of the educator, this work is a very complete treatise on the subject of hydraulics, especially suitable for students who have mastered an advanced course in mathematics, including the calculus. At the same time general students can readily follow the results given, and apply the necessary formulæ to the large number of practical examples included in the text. The definitions are very clear and direct, and this is of great importance in giving the student a proper conception of the physical processes involved in the various conditions of flow. I assume that the text is intended to be used in connection with an essentially practical course, with ample illustration and experiment, in fact, that it is simply one of the tools used to enable the University to graduate professional hydraulic engineers. With this fact in view, there seems to be no doubt but that the book serves its purpose extremely well.

There is one valuable feature ot the text which might have been extended with advantage; viz: The use of illustrations taken from working drawings and cuts of trade machines. In this respect all text-books I have seen are behind the times. The reproduction of such drawings is so simple and inexpensive that schematic drawings should be limited to illustrations requiring a separate discussion of individual features, and these should be additional to the complete drawings. Also, the scale should be large enough to prevent possible confusion or straining of the eyes. The size of the page should be determined from the necessity of sufficient illustration, whereas the usual plan is to subordinate the illustrations to a page selected on other considerations.

It goes without saying that a good course in mechanical drawing should be a part of any liberal education, and especially so in that which leads to a profession involving constructive work. Hence all text-books relating to the preparation for such a profession should present their subjects to the student in the most complete manner possible, not neglecting the symbols which he has already learned to interpret, and which show the relations of things in a language independent of words.

Another hopeful sign in the book is the very sparing use of the word "*Inertia*," a term whose utility is limited to the glittering generalities of popular speech.

W. B. G.

Catechism of Outpost Duty. Captain A. L. Wagner, 6th Infantry. Hudson-Kimberly Publishing Co., Kansas City, Mo.

This little hand-book is an abridgment in the form of questions and answers of the author's larger work on "The Service of Security and Information," and contains the essentials of that book. It is well arranged and will be of great assistance to those who desire to review the larger text-book or who wish to refresh their memories on some particular point. But it is not quite so much of an abridgment as it appears to be at first sight, since its actual

number of words is very nearly five-sixths of the original (omitting the questions in the back part); of course, the questions occupy a great deal of space, but still many of the answers could be abbreviated with great advantage.

Some of the questions have the fault ot being based entirely on the particular wording of the text-book, and would be unintelligible to one perfectly familiar with the subject, but who has not seen the author's "Security and Information."

We will give a few examples:

"Q. The information necessary for a commander is of what two kinds?

"Q. What would be the effect if troops moving in one body should come suddenly upon the enemy?

"Q. What important fact must be constantly considered in regard to the vanguard and the reserve?

"Q. What should the commander of the advance guard continually consider, and what, in general, should he do?

"Q. What is done when the advance guard halts?"

Every one of the questions assumes that the student has committed to memory the exact words of the text, otherwise he could not possibly answer them as desired. A slightly different wording, or an additional clause would make the question intelligible to any one who knows the subject.

Thus, if the question on p. 64. now reading:

"Q. Soon after the repulse of the attack, what should be done?"

which admits of a variety of correct answers, had added to it:

"To prevent the enemy from profiting by the information gained in the attack?"

It would be perfectly clear and admit of but one answer.

We call attention to the imperfections (and it is but fair to state that we have mentioned nearly all that there are) not only because they mar the clearness and system of this otherwise excellent and convenient little book, but also because there is danger that these questions may find their way into the examinations of officers for promotion.

J. P. W.

Aide-Mémoire de Manœuvres et de Campagne. Lieutenant-Général H. C. Fix. C. Muquardt, Brussels. 1895. Pp. 536.

This work, by one of the most prominent of the Belgian officers, the author of a well-known work on applied strategy, is designed to be a hand-book of reference for the Belgian officer in maneuvres and in actual campaigns, but has a considerable value for officers in general.

It is based on the best European manuals for *service in the field*, and on the works of Brialmont, Berthaut, Derrécagaix, Pierron, von der Goltz, De Heusch and others.

The text opens with an outline of the methods now in use for the concentration of the army, after its mobilization has been ordered; then proceeds to give a summary of the duties of the General Staff, and of the methods in vogue for the transmission of orders and reports. This is followed by an account of the service of intendance, the medical and veterinary service, safe-guards and military law, the pay department, and the railroad and telegraph service.

The tactics of the three arms are set forth in clear and concise language, including field fortifications and intrenchments for infantry and artillery, temporary bridges, and descriptions of the various kinds of regimental and

other wagons. The conduct of the division in battle is described in detail, followed by an excellent article on reconnoissances, and a full discussion of the minor operations of war, together with valuable notes on the estimation of distances, the supply of ammunition and the destruction of railroads.

A short chapter on orientation is followed by articles on the movements of troops (marches, the passage of rivers, etc.), cantonments, bivouacs, the supply of food and forage, advance-guards, the attack and defense of fortified places, and the hygiene of men and horses.

The entire work constitutes a complete hand-book for the officer in the field, and as it is a summary of the best military practice of the day it will be found exceedingly valuable for all officers.

J. P. W.

Das Englische Heer, Einschliesslich der Kolonialtruppen. Le Juge, Hauptmann à la suite des Kadettenkorps, Militär-lehrer bei der Haupt-Kadettenanstalt. Zuckschwerdt & Möschke, Leipzig. 1896. Pp. 141.

The armies of the continent of Europe have been studied with great care in the past few years, and many articles relating to their organization, strength and composition have been published, while England has generally been passed over. The present work is an attempt to supply the necessary information on this subject. It is based on the official English publications and on von Löbell's *Jahresberichte* and Lauth's *L'Etat Militaire des Puissances Etrangères*, and other standard works.

The author, in virtue of his position as instructor in the great German military academy at Gross-Lichterfelde, near Berlin, has had occasion to study the subject and consequently speaks with authority.

The work opens with a brief introduction, and comprises a clear account of the organization of the army, in general and in detail, tables of the strength of the separate parts, a description of the methods of recruitment, non-commissioned and warrant officers, commissioned officers, the supply of horses and the mobilization of the army; an account of the clothing, equipment aad armament of the army, its inner life (pay, food, quarters, instruction, discipline and punishments), the training of the troops, the firing and drill regulations, the military schools and camps of instruction and the maneuvers; closing with an account of the Indian army and the colonial troops.

It constitutes a valuable contribution to the military information series relating to the armies of our day.

J. P. W.

The Scientific American, 50th Anniversary Number, Munn & Co., 361 Broadway, New York. Price 10 cents.

A handsomely illustrated special number. Contents: (July 25, 1896.) The Transatlantic Steamship. Railroads and Bridges. The Telegraph. The Submarine Cable. Fifty Years of Photography. Chemistry. The Phonograph. The American Locomotive. The Bicycle. Electric Motors. Naval and Coast Defense. Steel. American Shipbuilding. Telephone. Fifty Years of the Scientific American.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6 *d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6 *d.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7 *s.*

United Service Gazette. [*U. S. Gazette.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C. Per year* £1 10 *s* 6 *d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*
17 *Great George Street, London, S. W. Per year* 2 *s.*

Army and Navy Gazette. [*A. and N. Gazette*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12 *s* 6 *d.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Journal of the United Service Institution of India. [*Jour. R. U. S. I. India*] *Monthly.*
Simla, India. Per year $2.50.

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6*d each.*

Electrical Review, [*Elec. Rev.*] *Weekly.*
22 *Paternoster Row, London. Per year* $6.00.

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris. Per year* 18 *Fr.*

Revue du Cercle Militaire. [*Cercle*] *Weekly.*
37 *Rue de Bellechasse, Paris. Per year* 27 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht*] *Weekly.*
55 *Rue de Chateaudun, Paris. Per year* 30 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
23 *Rue Madame, Paris. Per year* 30 *Fr.*

Revue Maritime et Coloniale. [*R. Maritime*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 56 *Fr.*

Revue d'Artillerie. [*R. Artillerie*] *Monthly.*
5 *Rue des Beaux-Arts, Paris. Per year* 22 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris. Per year* 27 *Fr.*

Revue Militaire de l'Etranger. [*Etranger*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 15 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
8 *Rue St. Dominique, Paris. Per year* 45 *Fr.*

Journal des Sciences Militaires. [*Sciences Militaires*] *Monthly.*
Rue et Passage Dauphine 30, *Paris. Per year* 40 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils. [*Ingénieurs Civils*] *Monthly.*
10 *Cité Rougemont, Paris. Per year* 36 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris. Per year* 33 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

GERMANY.

Militaer-Wochenblatt. [*Wochenblatt.*] *Fortnightly.*
Koch Strasse, 68, *Berlin, S. W.* 12. *Per Year* 20 *M.*

Archiv fuer die Artillerie-und Ingenieur Offiziere. [*Archiv.*] *Monthly.*
Koch Strasse, 68-78, *Berlin, S. W.* 12. *Per year* 12 *M.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin, W.* 8. *Per year* 32 *M.*

Marine Rundschau. [*Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W., Berlin.*

Deutsche Heeres Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens. [*Mitth. Art. u. G.*] *Monthly.*
Wien, VI, Getreidemarkt 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. Per year 12 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, Stauchgasse No. 4. *Per year*, 8-14 *numbers*, 6 *Fl.*

SWITZERLAND AND BELGIUM.

Schweizerische Zeitschrift fuer Artillerie und Genie. [*S. Zeitschrift.*] *Monthly.*
Frauenfeld, Switzerland. Per year 8 *Fr.* 20 *centimes.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, Switzerland. Per year 5 *Fr., plus postage.*

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, Switzerland. Per year, 8 *Fr.*

Revue Militaire Suisse. [*R. M. Suisse.*] *Monthly.*
Escalier-du-Marché, Lausanne, Switzerland. Per year 10 *Fr.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins, Liège, Belgium. Per year* 13 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles, Belgium. Per year* 12.50 *Fr.*

SPAIN, PORTUGAL AND SOUTH AMERICA.

Memorial de Artilleria. [*M. de Art.*] *Monthly.*
Farmacia, num. 13, *Madrid, Spain. Per year, U. S.,* $3.40.

Revista General de Marina, [*R. G. de Marina.*] *Monthly.*
56 *Calle de Alcalá, Madrid, Spain. Price U. S.* $4.45.

Revista Centifico-Militar. [*Centifico M.*] *Semi-monthly:*
5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

Revista do Exercito e da Armada. [*Exercito.*] *Monthly.*
Largo de S. Domingos No. 11, *Lisbon, Portugal. Per year U. S.* $6.00

Revista Militar. [*R. Mil. Portugal.*] *Semi-weekly.*
262 *Rua da Princeza, Lisbon, Portugal. Per year,* $2.60.

Revista Militar. [*R. Mil. Chile.*] *Monthly.*
Santiago, Chili.

Revista Maritima Brazileira. [*R.M. Brazil.*] *Bi-monthly.*
Rue do Conseheiro Saraiva n. 12, *Rio de Janeiro, Brazil. Per year* $10.00.

Revista da Commissao Technica Militar Consultiva. [*R. da Commissao.*] *Bi-monthly. Praça da Republica N.* 32, *Rio de Janeiro, Brazil.*

Circulo Naval,—Revista de Marina. [*R. de Marina.*] *Monthly.*
Casilla num. 852, *Valparaiso, Chili.*

Boletin del Centro Naval. [*Boletin.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00

El Porvenir Militar. [*Porvenir.*] *Weekly.*
258 *Calle Montevideo, Buenos Aires, Argentina.*

HOLLAND AND SCANDANAVIA.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland. Per year, U. S., $2.00.

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militeert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Stockholm, Sweden. Per year, U. S., $1.75.

ITALY.

Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

Rivista Marittima. [*R. Maritt.*] *Monthly.*
Rome. Per year 25 *L.*

UNITED STATES.

The Engineering News. [*Eng. News.*] *Weekly.*
Tribune Building, New York City. Per year $5.00.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* $3.00.

The Iron Age. [*Iron Age.*] *Weekly.*
96-102 *Reade Street, New York City. Per year* $4.50.

Journal of the Military Service Institution. *Bi-monthly.*
Governor's Island, New York City. Per year $4.00.

American Engineer and Railroad Journal. [*Eng. and Rail. Jour.*] *Monthly.*
47 *Cedar Street, New York City. Per year* $3.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

Electric Power. [*Elec. Power.*] *Monthly.*
27 *Thames Street, New York City. Per year* $2.00.

Digest of Physical Tests. [*Digest.*] *Monthly.*
1424 *N. 9th Street, Philadelphia. Per year* $1.00.

The Engineer. [*Eng. N. Y.*] *Fortnightly.*
106-108 *Fulton Street, New York City. Per year* $2.50.

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
World Building, New York City. Per year $3.00.

Journal of the American Chemical Society. [*J. Chem. S.*] *Monthly.*
Easton, Pa. Per year $5.00.

Journal of the Franklin Institute. [*Frank. Inst.*]
Per year $5.00.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] *Bi-monthly.*
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Pennsylvania Magazine of History and Biography. [*P. Mag. of Hist.*] *Quarterly.*
13 *Locust Street, Philadelphia. Per year* $3.00.

Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. Per year $3.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the U. S. Naval Institute. *Quarterly.*
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. *Per year* $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. *Per year* $3.00.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City.* *Per year* $3.00.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City.* *Per year* $2.50.

The United Service. [*U. Serv.*] *Monthly.*
1510 *Chestnut Street, Philadelphia.* *Per year* $2.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] *Quarterly.*
Navy Department, Washington, D. C.

ORGANIZATION AND ADMINISTRATION.

The future of the volunteers, England.—**A. and N. Gazette**, May 23.

The volunteers of to-day, England.—**Jour. R.U.S.I.**, May.

The Indian army of to-day.—**A. and N. Gazette**, May 30.

Indian army organization.—**U. S. Gazette**, May 30.

The English army in 1895.—**A. and N. Gazette**, June 6.

The military maneuvers bill, England.—**A. and N. Gazette**, June 13.

The Ordnance Department, England.—**A. and N. Gazette**, June 20.

Half pay system, England.—**U.S. Gazette**, May 23.

Half pay in the navy, England.—**A. and N. Gazette**, May 30.

Defense of the British Empire.—**Trans. East of Scotland Tactical Society**, April 30.

Defense of Canada.—**Can. Gazette**, June 15.

Functions of army and navy in defense of British Empire.—**U. S. Gazette**, June 6.

Means to secure a good navy personnel, England.—**Jour. R.U.S.I.**, May.

England's preparation against invasion.—**U. S. Gazette**, June 6.

Cost of English warships.—**Seewesens**, No. 7.

Notes on naval organization of England.—**R, Maritt.**, June.

Mounted infantry in England.—**Wochenblatt**, May 30.

Strengthening the U. S. Navy.—**A. and N. J.**, June 27.

United States coast defense.—**Bostonian**, May.

United States coast defense.—**Scien. Amer.**, June 13.

Organization, training, discipline of the navy personnel.—**Proc. U.S. Naval Institute**, No. 77.

The military and Naval power of the United States.—**M. de Art.**, May.

Military strength of the United States.—**Porvenir**, March 16.

Navy of the United States.—**R. G. de Marina**, May.

New navy of the United States.—**R.M. Brazil**, June.

United States naval budget 1896-97.—**Wochenblatt**, May 16.

Coast defense in the United States.—**Wochenblatt**, June 13.

Renovation of the corps of officers in the United States.—**Wochenblatt**, June 20.

Strength of the Spanish army.—**A. and N. J.**, June 13.

The Cuban army.—**R. G. de Marina**, May.

Military annual of Spain, 1896.—**Cercle**, May 30.

Strength of Spain upon mobilization.--**Wochenblatt**, April 29.
French naval budget, 1897.—**Seewesens**, No. 7.
The new French war ministry.—**A. M. Zeitung**, May 23.
Normandy in the defense of France.—**R. Univ.**, June.
Notes on the naval organization of Greece.—**R. Maritt.**, May.
Military organization in Greece.—**Etranger**, May.
Organization of the Medical Corps in Italy.—**Militärisches**, June.
Program of the new Italian war ministry.—**Wochenblatt**, April 22.
The Italian army and the proposed reforms of General Ricotti.—**Cercle**, June 6.
Organization of the Imperial troops in German East Africa.—**Wochenblatt**, April 1.
Transformation of the fourth battalion.—**A.M. Zeitung**, May 7.
A homogeneous fleet against specialized warships.—**U. S. Gazette**, June 6.
The composition and command of warships.—**Marine F.**, June 10.
War contributions and requisitions.—**R. Infanterie**, May 15.
A standing army or a militia.—**A.M. Zeitung**, April 2.
Duelling in the army.—**A. M. Zeitung**, April 20.
The duel question in the army.—**Heeres.-Zeit.**, June 20.
The Russian volunteer fleet.—**Rundschau**, May 7.
The army of the Mahdi.—**A. M.-Zeitung**, May 30.
Are specialist generals necessary?—**M. de Art.**, May.
Organization for the defense of important positions.—**R. Cientifico**, May 15.

TACTICS, STRATEGY AND MILITARY HISTORY.

Strategical questions in connection with India, Farther India and China.—**Aldershot**, February 4.
How Australia can help India.—**Jour. R.U.S.I., India**, April.
The Soudan expedition.—**A. and N. Gazette**, June 13.
The Egyptian question.—**Pub. Opin.**, May 21.
The Egyptian question.—**Avenir**, May 8.
The war in Soudan and Erythrea.—**A. Belge**, March-April.
First campaign of the English in Matabeland.—**Cercle**, May 16.
Spain's side of the Cuban question.—**Pub. Opin.**, June 4.
Cuban belligerency.—**Pub. Opin.**, June 18.
Military considerations on the campaign in Cuba.—**M. de Art.**, May.
Spain and the Cuban question.—**A. M.-Zeitung**, May 21.
The Italian-Abyssinian war.—**Militarisches**, June.
Critical study of the war between Abyssinia and Italy.—**R. Infanterie**, June 15.
The Italians in Africa.—**Etranger**, May.
The Italians in Erythrea.—**Cercle**, May 9.
The military situation in East Africa.—**A. M.-Zeitung**, June 13.
The Italian army in Erythrea and the Italian wars in Africa.—**Monatschr**, May.
The Italians in Erythrea.—**Belgique, M.**, May 31.
The French expedition to Madagascar.—**Vereine**, No. 3.
Losses of the French in the Madagascar campaign.—**A. M.-Zeitung**, April 20, May 11.
Difficulties in the occupation of Madagascar.—**Heeres-Zeit.**, June 17.
The Dutch in Atchim.—**Heeres-Zeit.**, June 3.
The war in Atjeh.—**A.M.-Zeit.**, May 23.

The battle of Austerlitz tactically considered.—**Proc. R.A.I.**, May.
Napoleon at St. Helena.—**Hamersly's U.S.**, June.
Suwarrows march through Switzerland.—**Vereine**, No. 5.
A study of the campaign of Soult in Portugal.—**Exercito**, May.
Tolstoi's "War and Peace" reviewed by Dragomiroff.—**Sciences Militaires**, April.
The autumn campaign of 1813 and interior lines.—**Sciences Militaires**, April.
From Lützen to Bautzen.—**R. Cavalerie**, April.
Operations of Napoleon in 1805.—**Heeres-Zeit.**, May 16.
Trafalgar.—**Rundschau**, June.
The battle of Ferket and its lessons.—**A. and N. Gazette**, June 20.
With Gibbon on the Sioux campaign of 1876.—**Jour. U.S. Cav.**, June.
Defenses of Philadelphia in 1777.—**Penn. Mag. of Hist.**, April.
U. S. Cavalry in Mexico.—**Hamersly's U.S.**, June.
Reminiscences of the Mexican campaign.—**R. Infanterie**, May 15.
The battle of St. Privat, August 18, 1870.—**A. Belge.**, March-April.
Capitulation of Metz.—**Zeitschrift**, May.
The navy in the defense of Paris in 1870.—**Sciences Militaires**, April.
Battles of the German army in their advance in 1870.—**Jahrbücher**, May.
Battle of Wörth, August, 1870.—**Jahrbücher**, May.
Campaign on the Loire, 1870.—**Heeres-Zeit.**, June 13.
The French army before 1870.—**Heeres-Zeit.**, May 20.
Moltke's correspondence, 1866.—**A.M.-Zeitung**, April 7.
Moltke's correspondence in 1870-71.—**A.M.-Zeitung**, May 28.
Moltke's military correspondence, 1870.—**Wochenblatt**, May 13.
An Italian view of von Moltke.—**Heeres-Zeit.**, May 13.
Recollections of the battle of Noisseville.—**Wochenblatt**, May 9.
Efficiency of the ambulance troops at Vionville and Mars-la-Tour.—**Wochenblatt**, April 29.
Storming of Chambord, December 9, 1870.—**Wochenblatt**, May 20.
Tactics of the future.—**A. and N. J.**, July 4.
Tactics of the future.—**Jour. R.U.S.I., India**, May.
Infantry fire tactics.—**Jour. R.U.S.I, India.**, April.
Garrison artillery warfare.—**Proc. R.A.I.**, May.
Sea-cost artillery fire control.—**Can. Gaz.**, May 15.
Artillery and musketry fire.—**Proc. R.A.I.**, May.
Infantry attack formations.—**Jour. M.S.I.**, July.
Difficulties of the defensive.—**U.S. Gazette**, May 23.
Strategic deployment of the French forces on the eastern frontier.—**R. M. Suisse**, June 15.
Tactics of ships in the line of battle.—**Proc. U. S. Naval Institute**, No. 77.
English opinions on naval tactics.—**R. de Marina**, April 30.
Résumé of foreign opinions on the naval questions of the Yalu.—**R. G. de Marina**, April.
Squadron tactics.—**R.G. de Marina**, May.
Battle of the Yalu.—**R.G. de Marina**, May.
Naval fight at Riachuelo.—**R.M. Brazil**, June.
Defensive and offensive armament at the battle of Yalu.—**Cercle**, June 13.
A descent into England.—**Militärisches**, June.
Infantry service in the field.—**Avenir**, June 7.
Strategy of combat.—(Lewal).—**Sciences Militaires**, April.

A study of cavalry in the advance.—**R. Cavalerie**, April.
Infantry against cavalry.—**A.M.-Zeitung**, June 13.
Value of the initiative in war.—**Jahrbücher**, May.
Strategical railroad system of France.—**Jahrbücher**, June.
Military operations and supplies.—**Wochenblatt**, April 22.
Infantry and artillery fire in action.—**Wochenblatt**, May 23.
Suggestions for playing Kriegspiel.—**Wochenblatt**, May 2.
Solution of tactical problems in the field.—**Wochenblatt**, June 10.

DRILL REGULATIONS AND MANEUVERS.

The New Forest maneuvers.—**Trans. East of Scotland Tactical Society**, April 30.
German maneuvers at Stettin.—**Trans. East of Scotland Tactical Society**, April 30.
Practice marches of light artillery.—**Jour. M.S.I.**, July.
Practical and theoretical instruction of troops.—**A. Belge**, March-April.
The grand French maneuvers of 1895.—**Exercito**, May.
Artillery maneuvers in the open country.—**R. Artillerie**, April.
Some German opinions on questions relating to field-artillery.—**R. Artillerie**, April.
Field shrapnel and the cannon of the future.—**R. Artillerie**, May.
The maneuvers and fire of groups of batteries in Russia.—**R. Artillerie**, May.
Practical artillery instruction in France and in Germany.—**R. Cercle**, May 30.
A report of Dragomiroff on the French exercises of 1895.—**A. M.-Zeitung**, April 20.
French campaign regulations.—**A.M.-Zeitung**, April 23.
German maneuvers in 1895 from an English standpoint.—**A.M.-Zeitung**, April 30.
Dragomiroff's system of army training.—**Jour. R.U.S.I., India.**

ARTILLERY MATERIAL.

Notes on explosives.—**Arms and Ex.**, May 1.
Transport of gun-cotton.—**Arms and Ex.**, June 1.
Cordite.—**Eng.**, May 13.
Dictionary of modern high explosives.—**R. G. de Marina**, May.
How to splice a rope.—**Eng. N.Y.**, June 6.
Wheeler-Sterling projectiles.—**Eng.**, May 15.
Breech mechanism of the 13-inch breech-loading gun, United States.—**Eng.**, May 15.
Manufacture of guns at the Washington Navy Yard.—**Scien. Amer.**, May 30.
The Ruelle works and the manufacture of naval cannon.—**Marine F.**, May 25.
The protection of steel and iron surfaces.—**U.S. Gazette**, May 30.
Turrets for battleships.—**A. and N. J.**, May 30.
Tests of Carnegie plates at Indian Head June 3, 1896.—**A. and N. J.**, June 6.
Bruff on ordnance and gunnery (a review).—**Iron Age**, May 21.
Turrets and disappearing carriages.—**Russian Artillery Journal**, February and March.
The Brown wire-wound gun.—**Seewesens**, No. 6.
Explosive fuse of Major Eneas.—**A. Belge**, March-April.
The automatic mitrailleuse.—**A. Belge**, March-April.
Design of a new obturating ring for breech-loading cannon.—**M. de Art.**, April.

Machine guns.—**M. de Art.**, April.

Note on United States coast coast fortifications and Artillery.—**M. de Art.**, April.

The naval artillery of the United States.—**M. de Art.**, May.

Field artillery of the near future.—**R. Artillerie**, June.

German field artillery material.—**R. Artillerie**, June.

Detailed accounts of improvements and modifications in cannon and small arms.—**Kriegswaffen**, No. 10.

BALLISTICS, RANGE FINDING AND POINTING.

Sea-coast artillery fire control.—**Can. Gaz.**, May 15.

Barr and Stroud naval range-finder.—**Eng'ing**, June 19.

Considerations on the subject of trajectories.—**Proc. R.A.I.**, May.

The causes of drift.—**Proc. R.A.I.**, May.

A Russian range-finder.—**A. and N.R.**, June 6.

A naval system of aiming drill.—**Proc U.S. Naval Institute**, No. 77.

Graphic tables of fire for sea-coast mortars.—**Russian Artillery Journal**, March.

Notes upon methods for studying the results of firing.—**Russian Artillery Journal**, February.

Influence of the electrical current on precision of fire.—**Russkii Invalid**, No. 102.

The different systems in Austria, Italy, France, Holland and Sweden for working and firing the coast-artillery.—**Mitth. Art. u. G.**, No. 4.

The most suitable arrangement for infantry rifle practice.—**Mitth. Art. u, G.**, No. 4.

The proper method of studying artillery firing.—**Vereine**, No. 4.

Course of artillery firing instruction, Italy (note).—**A. Belge**, March-April.

Movement of ogival projectiles about their center of gravity.—**M. de Art.**, May.

A ballistic problem applied to a question in fortification (De la Llave).—**R. Centifico**, May 15.

Telemeters, **R.G. de Marina**, June.

The solution of the ballistic problem.—**R. Artig.**, May.

Calculation of the trajectory by points.—**R. Artig.**, May.

Resistance of the air to the motion of projectiles.—**R. Artig.**, March.

The best methods of converging the fire of batteries.—**R. Artig.**, March.

A new study of exterior ballistics by Siacci.—**R. Artillerie**, May.

A new telemeter.—**R. Maritime**, May.

The Lüttig instrument for measuring distances.—**Wochenblatt**, April 22.

Influence of wind on a bullet's trajectory.—**Wochenblatt**, April 29.

The representation of the target in field artillery practice.—**Wochenblatt**, June 13.

A better representation of the target for field artillery.—**Wochenblatt**, June 13.

METALLURGY.

Transmission of heat through steel plates.—**Eng.**, May 22.

The hardening of steel.—**Eng'ing**, May 22, June 5.

New Zealand iron sands.—**Eng'ing**, June 5.

Casting of aluminum.—**Eng. Rev. London**, June 20.

Making of steel forgings in America.—**Cas. Mag.**, June.

Hollow steel forgings.—**Iron Age**, May 28.

ELECTRICITY AND HYDRAULICS.

Motor development in men-of-war.—Elec. Rev., April 3.
Elisha Gray telautograph.—Eng'ing, June 5.
Electric ventilators.—Jour. R.U.S.I., May.
Military telephony.—Heeres-Zeit., June 13.

FORTIFICATION.

The new works at Gibralter (map).—Marine F., May 25.
Organization for the defense of important positions.—R. Cientifico, May 15.
The Russian fortress Oust Dvinsk.—Génie M., May.
Uses of permanent works.—Heeres-Zeit., June 17.

BICYCLES—ÆROSTATION—PHOTOGRAPHY.

The sailing flight of birds.—Eng'ing, May 29.
The bicycle for war.—A. and N. J., June 20.
Langley's flying machine.—Pub. Opin., June 4.
Military bicycles in America.—Razviedschiek, St. Petersburg, No. 288.
Recent progress in the domain of photography.—Vereine, No. 4.
Military cyclists in France.—R.M. Suisse, June 15.
The military bicycle.—Belgique M., May 31.
The bicycle in the 12th French Army Corps.—Belgique M., May 31.
An account of three ballon ascensions in 1895.—Génie M., May.
A riding school for military wheelmen.—A.M.-Zeitung, April 26.

SMALL ARMS AND EQUIPMENTS.

Tests of American rifles for N. G. N. Y.—Eng., June 5.
A paper on pistols.—U. S. Gazette, May 16.
Development of the pistol.—U.S. Gazette, May 16.
The modern small bore bullet.—A. and N. J., June 20.
Tests of the Krag-Jorgensen rifle on dead bodies.—A. and N. J., June 27.
Tests of military rifles for the N. Y. National Guard.—Shooting and Fishing, May 21.
Lead bullets for the .30 caliber rifle.—Shooting and Fishing, June 4.
The .25 caliber rifle.—Shooting and Fishing, June 18.
The Mauser rifle and its evolution.—R. da Commissao, March-April.
New small arms and new conditions of combat.—R. da Commissao, March-April.

MILITARY GEOGRAPHY.

Russia in the Pacific.—A. and N. Gazette, June 6.
Thames and Severn canal.—Eng., May 8.
Manchester ship canal.—Eng., May 15.
Preston and the Ribble navigation.—Eng., May 15.
The Jonage canal, France.—Eng., May 29.
Maritime position of Hamburg.—Eng., June 12.
Future route to Italy.—Eng., June 19.
Railways in Asiatic Turkey.—Eng., June 5.
Nicaragua canal estimates.—Eng. News, June 18.
Suez canal traffic.—Iron Age, June 11.
Navigation of the Suez canal, 1895.—R. Maritt., April.
Completion of Canada's canals.—Mar. Rev., June 4.
How the great lakes were built.—Pop. Sc. Mo., June.
Articles on Alaska.—Rev. of Rev., June.

The lake of Nemi.—**R. Maritt.**, June.

Proposed canal between the Atlantic and the Mediterranean.—**Avenir**, June 6.

Madagascar.—**R. Maritime**, April.

The new harbor at Libau.—**R. Maritime**, April.

The Suez canal.—**R. Maritime**, May.

The new French port of Bizerte.—**Yacht**, May 30.

German East Africa.—**Rundschau**, June.

The kingdom of the Mahdi.—**Wochenblatt**, June 3.

MILITARY SCHOOLS.

The U. S. Naval War College.—**Proc. U.S. Naval Institute**, No. 77.

A few words relative to artillery instruction.—**Russian Artillery Journal**, February.

Naval War College, France.—**R. G. de Marina**, April.

Regulations for the Argentine Military College.—**Porvenir**, April 16.

The French Naval War College.—**R. G. de Marina**, May.

The Saint-Cyr examinations.—**Avenir**, June 23.

WARSHIPS AND TORPEDO-BOATS.

Torpedoes and torpedo-boats (a review).—**Eng.**, May 15.

Argentine cruiser *Buenos Aires*.—**Eng'ing**, May 29.

Design of warships.—**Eng'ing**, June 5.

New cruiser *Niobe* for British navy.—**Eng'ing**, June 5.

Machinery of new English cruisers.—**Eng'ing**, June 26.

The English cruiser *Terrible*.—**Génie C.**, June 13.

Italian ships of the first class.—**Seewesens**, No. 6.

German war vessels.—**Eng'ing**, June 19.

Value of torpedo-boats.—**U.S. Gazette**, May 30.

Requirements for the new U. S. battleships.—**A. and N. J.**, July 4.

Trial trip of the *Oregon*.—**A. and N.J.**, June 20.

Battleships 7, 8 and 9.—**A. and N. R.**, June 27.

Trial of the battleship *Massachusetts*.—**Journal Amer. Soc. Naval Engineers**, May.

The battle of the Yalu and its effect on the construction of warships.—**Journal Amer. Soc. Naval Engineers**, May.

Notes on American and foreign warships.—**Journal Amer. Soc. Naval Engineers**, May.

The U. S. battleship *Kearsarge*.—**Scien. Amer.**, June 25.

A method of calculating the fighting power of a ship.—**R. M. Brazil**, June.

Notes on the large cruisers of the various powers.—**Ingénieurs Civils**, April.

Cruisers of the *Bugeaud* type.—**Marine F.**, May 25.

Transformation of the *Foudre*.—**Yacht**, May 9.

Problem of the best battleships.—**Yacht**, May 23.

The French battleship *Redoutable*.—**Yacht**, May 23.

Trials of the *Jauréguiberry*.—**Yacht**, May 30.

The Holland submarine torpedo-boat.—**Yacht**, June 6.

History for Ready Reference

and Topical Reading.

IN FIVE IMPERIAL VOLUMES.

By J. N. LARNED, *Ex-Pres. Am. Library Ass'n.*

☞ Giving History on All Topics in the Exact Words of the Historians Themselves.

This work contains the choicest selections, upon thousands of topics, from those historians whose writings have been accorded the highest place by the common consent of mankind.

It will answer more questions in History, more authoritatively, with greater excellence of literary expression, and with a greater economy of time, than any library, or even all other books in the world.

Supt. GEO. J. LUCKEY, Pittsburgh.

Larned's History for Ready Reference has done more to make the study of history easy and fascinating than any other work yet published.

Any event, however obscure, can be found as easily as a word in the dictionary; the different views of many historians can be compared on all disputed questions; the contemporaneous history of different countries can be readily obtained; and all this, not in a dry compilation of facts and dates, but in the **exact language** of the most inspired writers of ancient and modern times.

The excellent, comprehensive colored maps—**picture histories**—enabling the reader to compass with a glance what could be understood from a verbal description only by the most laborious study, while the outlines afford a novel and effective means of welding together events into a logical chain of sequence.

These, together with many special features, such as—**the exact text of all national constitutions and great historical documents,** the extensive chronologies, and classified bibliographies, the bringing of all history down to date in the latest pages of the last volume, make the work invaluable, not only to the scholar, but also to every man who desires himself to be, or to have his children become, useful and intelligent citizens.

Supt. W. B. POWELL, Washington, D. C.

It has made it possible for me to see and readily use my own library in its connected and sequential aspect as I have never before been able to do.

Supt. THOMAS M. BALLIET, Springfield, Mass.

The book is in every way unique and remarkable. It not only groups together the most trustworthy information on nearly every topic in history which one could find only with difficulty and at great expense of time in the standard histories, but puts [illegible] the great events of history in a way to give the past three thousand years in the smallest compass.

As a time-saving work to the busy man of affairs or to the student, I know of nothing else at all equal to it.

Sent Carriage Free to responsible subscribers on **easy payments.** Send for circular, *giving full information.*

SOLICITORS EMPLOYED.

The C. A. Nichols Co., Publishers,

Springfield, Mass.

SEPTEMBER—OCTOBER.

Vol. VI. No. 2. Whole No. 22.

1896.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS.

UNITED STATES ARTILLERY SCHOOL,

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School.

COMMITTEE OF DIRECTION AND PUBLICATION:

Captain James M. Ingalls, 1st U. S. Artillery,
Lieutenant Erasmus M. Weaver, 2nd U. S. Artillery,
Lieutenant George O. Squier, 3rd U. S. Artillery,
Lieutenant Edgar Russel, 5th U. S. Artillery.

EDITOR.

Lieutenant John P. Wisser, 1st U. S. Artillery.

ASSISTANT EDITOR.

Lieutenant Andrew Hero, Jr., 4th U. S. Artillery.

Subscription - $2.50
For countries in the postal union - - - - - - - - - - - - - $3.00
Single numbers - $0.50

Subscriptions in all cases date from January 1st, and remittances should be sent to the editor at Fort Monroe, Virginia.

AGENTS.

NEW YORK—*Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254 5th Avenue.
LONDON—*B. F. Stevens*, 4 Trafalgar Square.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. VI. No. 2. SEPTEMBER—OCTOBER, 1896. WHOLE No. 22.

ON THE RIFLING OF CANNON.

Advantages of rifling.—The superiority of oblong over spherical projectiles is two-fold. In the first place they have greater ballistic efficiency,—that is, for the same caliber, muzzle velocity and range, an oblong projectile has a higher *average* velocity during its flight than a spherical projectile. This gives to the former a flatter trajectory which increases the probability of hitting the target. Experimental firing has demonstrated that the mean deviation of a rifled gun at medium ranges, when all known and controlable causes of deviation have been eliminated, is only one-third that of a smooth-bore. This advantage results both from the greater sectional density of the oblong projectile whereby it is enabled the better to overcome the resistance of the air, and also because this resistance is diminished on account of the more pointed head which is given to these projectiles.

In the second place the penetrating power of oblong projectiles, other things being equal, is much greater than can be realized with spherical shot, while the bursting charge of oblong *shells* is as great or even greater than for spherical shells on account of the greater length of the former.

These are very substantial advantages; but to secure them it is essential that the oblong projectile keep point foremost in its flight through the air; for otherwise it would have neither range, accuracy nor penetration, but would waste nearly all its gy beating the air.

ie only way to secure steadiness of flight to an oblong proile and to keep its geometrical axis in the tangent to the tratory it describes, is to give it a high rotary velocity about this s. This is accomplished by rifling, as it is called,—that is, by ting spiral grooves in the walls of the bore, into which the jecting copper band, securely encircling the projectile near

its base, is forced as soon as motion of translation begins, thus giving to the projectile a rotary motion in addition to its translation, as it moves down the bore. The rifling may be such that the grooves (or rifles) have a constant pitch, that is, make a constant angle with the axis of the bore; or this angle may be variable. In the first case the gun is said to be rifled with a uniform *twist;* and in the second case with an increasing twist. In all cases the twist at any point of the bore is measured by the linear distance the projectile advances while revolving once about its axis, supposing the twist at that point to remain uniform. This linear distance is always expressed in calibers, and is therefore independent of the unit of length employed.

The Developed Groove. Uniform Twist—The element of a groove of uniform twist developed upon a plane is evidently a right line AC making with the longitudinal element of the surface of the bore AB, prolonged beyond the muzzle, the constant angle BAC, whose tangent is BC/AB.* Suppose AB to be the longitudinal element passing through the beginning of the groove A, which is near the base of the projectile when in its seat and directly in front of the copper, or rotating band. Make $AB = nd$, n being the number of calibers the projectile travels while making one revolution about its axis. Then BC will be equal to the circumference of the projectile, or $BC = \pi d$. If we designate the angle of inclination of the groove BAC by β we shall have the relation

$$\tan \beta = \frac{BC}{AB} = \frac{\pi d}{n d} = \frac{\pi}{n} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

Increasing Twist.—With a uniform twist the maximum pressure produced on the lands in giving rotation to the projectile and in overcoming friction and other passive resistances, occurs (as will be shown presently) at the point of maximum effective pressure of the powder gases on the base of the projectile, which point, as we know, is near the beginning of motion. From this point the pressure on the lands decreases to the muzzle where it is not generally more than one-fourth of its maximum value. It is considered by gun makers a desideratum to have the pressure on the lands as uniform as possible, and to this end recourse is had to an increasing twist,—that is, the angle which a groove makes with the axis of the bore instead of being constant as with a uniform twist, increases in value from the beginning of rifling at the breech end of the gun toward the muzzle. If this variable angle be represented by θ we shall have, as before,

* The simple diagrams required in this article can easily be constructed by the reader.

$$\tan \theta = \frac{\pi}{n}$$

in which n is in this case a variable number, decreasing in value as the distance from the origin of rifling increases. If as before we take the origin of rectangular coordinates at A, the beginning of rifling, and suppose AB to be a longitudinal element of the bore and BC the length of arc revolved through by a point on the surface of the projectile while in the bore (BC is always less than the circumference πd), then the developed groove AC is, for an *increasing* twist, a curve convex toward AB, the axis of abscissas, for the reason that by definition tan θ increases from A towards B. For a *decreasing* twist the developed groove would be concave toward the axis of X for a similar reason. The two forms of increasing twist which have been generally adopted are the parabolic and circular, though these curves are not necessarily the best for the purpose. But before attempting to decide upon the best system of rifling, it will be necessary to deduce an expression for the normal pressure exerted by the lands upon the rotating band at any point of the bore.

Pressure on Lands. Increasing Twist.—The angular velocity ω of a projectile about its geometrical axis while moving along the bore, continually increases from zero to its muzzle value, which is $\pi V/nr$, V being the muzzle velocity of translation and r the radius of the projectile. Its magnitude at any instant is given by the equation

$$\omega = \frac{d\varphi}{dt},$$

where φ is the angle turned through from the beginning of motion expressed in radians. The angular acceleration is found by differentating this equation with respect to the time, which gives

$$\text{Angular acceleration} = \frac{d\omega}{dt} = \frac{d^2\varphi}{dt^2} \quad . \; . \; . \; . \; . \; . \quad (2)$$

If x and y are the rectangular coordinates of the developed groove, with the origin of coordinates at the beginning of rifling, and if the axis of abscissas is parallel to the axis of the bore, then x will be at any instant the distance traveled by the shot, and the corresponding value of y will be $r\varphi$, where r is the radius of the projectile. Substituting y for φ in equation (2) the expression for the angular acceleration becomes

$$\frac{d\omega}{dt} = \frac{1}{r}\frac{d^2y}{dt^2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (3)$$

If P is the total effective pressure of the powder gases on the base of the projectile,

R the normal pressure of the rotating band against the bearing surfaces of the grooves,

k the radius of gyration of the projectile,

f the coefficient of friction,

then the equations of motion of the projectile along the bore are (Chapter VI),*

$$M\frac{d^2x}{dt^2} = P - R(\sin\theta + f\cos\theta) \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and

$$Mk^2\frac{d\omega}{dt} = rR(\cos\theta - f\sin\theta) \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

or, from equation (3), and making $\mu = k^2/r^2$,

$$M\mu\frac{d^2y}{dt^2} = R(\cos\theta - f\sin\theta) \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

We will assume that the entire work of the powder gases upon the projectile is consumed in giving to it motion of translation and of rotation and in overcoming passive resistances, and further that these last may all be summed up as *friction* and be included in the coefficient of friction f. Let P_t be the part of the effective pressure on the base of the projectile producing translation and P_r the part producing rotation and overcoming friction. Then

$$M\frac{d^2x}{dt^2} = P_t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and

$$P = P_t + P_r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Therefore from equation (4)

$$P_r = R(\sin\theta + f\cos\theta) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Let

$$y = f(x)$$

be the equation to the developed groove. Then, employing the usual notation,

$$\frac{dy}{dx} = f'(x) = \tan\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

and

$$\frac{d^2y}{dx^2} = f''(x) = \frac{d\tan\theta}{dx}.$$

Also, since

$$\frac{dy}{dt} = \frac{dy}{dx}\cdot\frac{dx}{dt} = f'(x)\frac{dx}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

* This and other similar references are to the author's Interior Ballistics; and this paper is intended to be substituted for Chapter VII of that work.

we have

$$\frac{d^2 y}{dt^2} = f'(x)\frac{d^2 x}{dt^2} + f''(x)\left(\frac{dx}{dt}\right)^2$$

$$= \frac{P_t}{M}\tan\theta + v^2 f''(x) \quad \ldots\ldots\ldots (12)$$

Therefore, from equation (6),

$$\mu\,(P_t \tan\theta + M v^2 f''(x)) = R\,(\cos\theta - f\sin\theta)$$

whence, by a slight reduction,

$$R = \frac{\mu \sec\theta\,(P_t \tan\theta + M v^2 f''(x))}{1 - f\tan\theta}$$

or, putting

$$K_1 = \frac{\sec\theta}{1 - f\tan\theta}$$

we have, finally, the working expression

$$R = K_1 \mu\,(P_t \tan\theta + M v^2 f''(x)) \quad \ldots\ldots (13)$$

In using equation (13), $\tan\theta$ and $f''(x)$ are obtained from the equation to the developed groove if this be first assumed, as is generally the case. On the other hand if the most suitable value or values for R are first decided upon, then equation (13) will be of assistance in determining the proper curve for the developed groove. The factors μ and M are given by the projectile, v and P_t are determined for any position of the projectile in the bore by means of the equations for velocity and pressure deduced and fully illustrated in Chapters IV and V, while the coefficient of friction f must be found by experiment.

Surface Acceleration of Rotation of a Projectile about its Geometrical Axis.—Let v_r be the normal velocity of rotation of a point on the surface of a projectile at the instant when its velocity of translation along the bore is v. Then if θ is the inclination of the grooves at the point under consideration, we shall have from equation (11)

$$v_r = v\tan\theta \quad \ldots\ldots\ldots\ldots (14)$$

The acceleration of v_r (or surface acceleration) due either to a variation of v, or of θ, or of both, is found by differentiating equation (14) with reference to t. Calling this acceleration γ_r we have

$$\gamma_r = \tan\theta\,\frac{dv}{dt} + v\,\frac{d\tan\theta}{dt}.$$

But $\frac{dv}{dt}$ = acceleration of translation $= \frac{P_t}{M} = \gamma$ (say) and

$$\frac{d\tan\theta}{dt} = \frac{d\tan\theta}{dx}\cdot\frac{dx}{dt} = v f''(x).$$

Therefore

$$\gamma_r = \gamma \tan \theta + v^2 f''(x) \quad \text{. . . . .} \quad (15)$$

Comparing equations (13) and (15) we find

$$R = K_1 M \mu \gamma_r \quad \text{. . . . .} \quad (16)$$

that is, the pressure on the lands of guns having an increasing twist is K_1 times that required simply to rotate the projectile. Equation (15) comes of course directly from equations (3) and (12), since

$$\gamma_r = r \frac{d\omega}{dt} = \frac{d^2 y}{dt^2} \quad \text{. . . . .} \quad (17)$$

It will be seen that for small values of θ the coefficient K_1 is but slightly greater than unity, this being its initial value in those cases where (as with some of our naval guns, for example) the rifling begins with a zero twist. But if we should make K_1 unity for the entire increasing twist, for the purpose of simplifying the calculations, the resulting values of R would be but rough approximations, not so close indeed as they would be if all consideration of the friction were omitted.

Uniform Twist.—For a rifling of uniform twist $f''(x)$ is zero and θ a constant angle usually designated by β. Making these changes equation (13) reduces to

$$R = K_2 \mu P_t \quad \text{. . . . .} \quad (18)$$

in which K_2 is a constant whose value is

$$K_2 = \frac{\tan \beta \sec \beta}{1 - f \tan \theta} = \frac{\sec \beta}{\cot \beta - f}.$$

For a uniform twist the coefficient of friction as determined by Noble's experiments with 12-cm Q. F. guns is 0.2; and if the twist is one turn in 25 calbers we also have from equation (1)

$$\tan \beta = \frac{\pi}{25},$$

whence

$$\beta = 7^\circ\ 9'\ 48.''4,$$

whence we find

$$K_2 = 0.13.$$

Therefore for this twist the pressure on the lands is given by the very simple equation

$$R = 0.13 \mu P_t \quad \text{. . . . .} \quad (19)$$

In the second member of equation (19) the factor P_t is, for the same projectile, the only variable, and therefore R is nearly proportional to the pressure on the base of the projec tile and is a maximum when this pressure is a maximum, that is, very near the beginning of motion. In equation (13) there are

generally four variables in the second member, namely, P_{t}, v, θ and $f''(x)$; and it is not obvious from simple inspection of the formulae where the point of maximum rotation will be located. It will be shown however by examples that for an increasing twist this point is much nearer the muzzle than when the twist is uniform.

Forms of Rifling Curves which have been adopted. Parabolic Rifling.—To continue an increasing twist quite up to the muzzle must conduce to inaccuracy of flight, and especially so when the projectile has partially left the bore so that it has lost its centering.

To remedy this the acceleration of rotation near the muzzle is either made zero or constant (preferably the former) in order to relieve the rotating band as much as possible from pressure. In all our sea-coast B. L. rifles the final twist is made constant, beginning at two calibers from the muzzle. The developed groove for the increasing twist is a semi-cubical parabola whose general equation is

$$y + b = p(x + a)^{\frac{3}{2}} \quad \ldots\ldots\ldots \quad (20)$$

The axis of x is parallel to the axis of the bore and the origin is at the beginning of rifling, that is, just in front of the rotating band when the projectile is in its firing seat. The coordinates of the vertex of the parabola are $-a$ and $-b$; and these, together with the parameter p, are determined by the particular twist adopted for the beginning and ending of the increasing twist. Suppose the rifling to start with a twist of one turn in n_1 calibers, and that at two calibers from the muzzle where the rifling begins to be constant, it has a twist of one turn in n_2 calibers ($n_1 > n_2$). For these two points we have, respectively,

$$\tan\theta_1 = \frac{\pi}{n_1}, \text{ and } \tan\theta_2 = \frac{\pi}{n_2},$$

θ_1 and θ_2 being the inclinations of the grooves at the points considered. Differentiating equation (20) we have generally

$$\tan\theta = \frac{dy}{dx} = \tfrac{3}{2}p(x + a)^{\frac{1}{2}} \quad \ldots\ldots\ldots \quad (21)$$

At the origin $x = 0$, which gives

$$\tan\theta_1 = \tfrac{3}{2}p\sqrt{a} = \frac{\pi}{n_1}.$$

At two calibers from the muzzle where the increasing twist ends, $x = u_2$, and we have in order to determine the value of θ_2 the equation

$$\tan\theta_2 = \tfrac{3}{2}p(u_2 + a)^{\frac{1}{2}} = \frac{\pi}{n_2}.$$

From these last two equations we easily find

$$a = \frac{u_2}{\left(\frac{n_1}{n_2}\right)^2 - 1} \quad \ldots\ldots\ldots\ldots (22)$$

and

$$p = \frac{2\pi}{3 n_1 \sqrt{a}} = \frac{2\pi}{3 n_2 \sqrt{u_2 + a}} \quad \ldots\ldots\ldots (23)$$

Since at the origin of coordinates x and y are both zero, we find from equations (20) and (23)

$$b = \frac{2\pi a}{3 n_1} \quad \ldots\ldots\ldots\ldots (24)$$

And thus all the constants of the equation to the developed groove are determined in terms of n_1, n_2 and u_2. Differentiating equation (21) gives, lastly,

$$f''(x) = \frac{3p}{4\sqrt{x+a}} \quad \ldots\ldots\ldots\ldots (25)$$

Modified Form of Parabolic Rifling.—If a and b are each made zero in equation (20) it becomes

$$y = p x^{\frac{3}{2}} \quad \ldots\ldots\ldots\ldots (26)$$

which is the equation to the developed groove when the vertex of the semi-cubical parabola is at the origin or beginning of rifling. In this case the twist increases from zero at the origen to one turn in n_2 calibers near the muzzle. The values of tan θ, p and $f''(x)$ for this particular form of rifling are easily deduced from equations (21), (23) and (25) by simply making a zero. This form of groove is that adopted by the navy for all their larger guns of recent construction.

With some foreign guns the developed groove is the common parabola whose equation is

$$y + b = p(a + x)^2 \quad \ldots\ldots\ldots\ldots (27)$$

The constants are determined as already explained and are as follows:

$$a = \frac{u_2}{\frac{n_1}{n_2} - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (28)$$

$$b = \frac{\pi a}{2 n_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (29)$$

$$p = \frac{\pi}{2 a n_1} = \frac{\pi}{2 n_2 (a + u_2)} \quad \ldots\ldots\ldots\ldots (30)$$

$$f''(x) = 2p \quad \ldots\ldots\ldots\ldots\ldots\ldots (31)$$

For this form of groove equation (13) becomes

$$R = \mu K_1 \left\{ P_t \tan \theta + 2 p M v^2 \right\} \quad \ldots\ldots (32)$$

Circular Rifling.—If the developed groove of an increasing twist be the arc of a circle whose initial inclination to the axis of the bore is θ_1 and final inclination θ_2, its equation referred to rectangular axes similar to those already explained for the semi-cubical parabola is

$$(b - y)^2 = r^2 - (x + a)^2 \quad \ldots\ldots\ldots (33)$$

in which r is the radius of the circle and $a = r \sin \theta_1$ and $b = r \cos \theta_1$ are the coordinates of the center taken with the negative sign. The geometry of the circle gives the relation

$$r \sin \theta_2 - r \sin \theta_1 = u_2,$$

whence

$$r = \frac{u_2}{2 \sin \frac{1}{2} (\theta_2 - \theta_1) \cos \frac{1}{2} (\theta_2 + \theta_1)} \quad \ldots\ldots (34)$$

Finally, the differential of equation (33) gives

$$\tan \theta = \frac{x + a}{b - y} \quad \ldots\ldots\ldots\ldots (35)$$

and

$$f''(x) = \frac{d \tan \theta}{dx} = \frac{1 + \tan \theta}{x + a} \quad \ldots\ldots\ldots (36)$$

Relative width of Grooves and Lands in our service Siege and Sea-coast guns.—In our service siege and sea-coast guns the number N of grooves (or lands) is given by the equation

$$N = 6\,d,$$

in which d is the diameter of the bore in inches, and is a whole number for each of these guns. If w_g is the width of a groove and w_l the width of a land, we evidently have the relation

$$w_g + w_l = \frac{\pi d}{6 d} = \frac{\pi}{6} = 0.5236 \text{ inches.}$$

The best authorities lay down the rule that the width of a groove should be at least double that of a land. In our guns the lands are made 0.″15 wide and the grooves are therefore 0.″5236 — 0.″15 = 0.″3736 wide.

For the 5″ siege gun and 7″ siege howitzer the grooves are 0.″05 deep. For the 8″, 10″ and 12″ sea-coast rifles the grooves are 0.″06 deep, and for the proposed 16″ rifle the depth will be 0.″07.

Application of the preceding formulae to the 10-inch sea-coast rifle.—The 10-inch B. L. guns now in process of construction for the

SEPTEMBER—OCTOBER.

Vol. VI. No. 2. Whole No. 22.

1896.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS,
FORT MONROE, VIRGINIA.

ENTERED AT THE POSTOFFICE AT FORTRESS MONROE, VA., AS SECOND-CLASS MATTER

theory. By the methods referred to the constants for the gun and powder, M_1 and N_1, are deduced from a single round by means of the measured mzzzle velocity in connection with the maximum pressure in the chamber of the gun as shown by the crusher gauge, the Sebert velocimeter or other apparatus. These constants, together with the other known constants relating to the gun, projectile and charge, substituted in equations (39) and (40) of Chapter IV, page 84, give working expressions for the velocity and corresponding pressure at any point of the bore. These equations necessarily reproduce the muzzle velocity and maximum pressure which determined M_1 and N_1, and they also locate the position of maximum pressure correctly so far as it has been possible to determine this position experimentally. Moreover these equations make the velocity and pressure zero at the origin of motion. We therefore have an expression for the velocity in terms of the number of volumes of expansion of the powder gases which gives the true velocity at three points within the bore, namely, at the origin of motion, at the point of maximum pressure (which is very near the origin) and at the muzzle. Whether the theoretical functions X_0 and X_1 vary in such a way as to give the true velocity of the projectile from the point of maximum pressure to the muzzle, must be ascertained by a comparison of computed with such measured velocities as have been determined by experiment. If the computed velocities are correct the corresponding valnes of P_t are necessarily so since the pressure formula was deduced by equation (38).

Velocities of projectiles in the bores of guns have been measured more or less indirectly and accurately by several experimenters, some of whom determined the velocities first independently of the pressures, while others deduced the pressures first and from these computed the corresponding velocities. In all cases where the necessary data were accessible the experimental velocities have been recomputed by the method of Chapter V, for comparison; and the results seem to justify a great degree of confidence in our method. The following comparisons have been made:

1. With those determined by the English "Committee of Explosives," of which Colonel Younghusband, F. R. S., was president. These are given in detail in Chapter IV.

2. Velocities measured in a 65 mm. Hotchkiss R. F. gun, in February and April, 1889, by Benét, at the Hotchkiss works, Paris.*

* For a full account of these experiments see Notes on the Construction of Ordnance, No. 54.

3. Benét's experiments with a 57 mm. Hotchkiss R. F. gun in the summer of 1891.* In both these series of experiments Benét employed D'Arcy's method for measuring the velocity.

4. Velocities determined indirectly by the recoil of a 10-cm. gun as measured by a Sebert velocimeter in April, 1880, at the firing grounds of Sévran-Livry, by Sebert and Hugonoit.†

In all these cases the velocities computed by the method here adopted, agree practically with the experimental velocities from at, or near, the point of maximum pressure to the muzzle, the differences averaging considerable less than one per cent.

For the 10-inch B.L.R. we have the following data: $\tilde{\omega} = 250$ lbs., $w = 575$ lbs., $d = \frac{5}{6}$ feet, $C = 7064$ c. inches, $U = 22.925$ feet and $V = 1975$ f. s. The density δ of the powder is 1.82 and the grains are of the pierced prismatic form, so that $a = \frac{3}{2}$, $\lambda = \frac{1}{3}$ and $\mu = o$. The maximum pressure in the powder chamber measured by a crusher gauge is 37,000 lbs. per square inch, and we will assume that reducing this 10 per cent. gives the maximum effective pressure on the base of the projectile, or $p_m = 33300$ lbs. per square inch. We now have all the data required for computing M_1 and N_1 by means of equations (12) and (13) of Chapter V. The principal results of the calculations are the following: $\Delta = 0.97964$, $\log z_0 = 0.53918$, $X = \frac{U}{z_0} = 6.6240 =$ number of volumes of expansion of the powder gases at muzzle, and, corresponding to X, $\log X_0 = 0.82938$ and $\log X_1 = 0.52127$. Next, by means of the formulas of Chapter V we compute $m = 0.84102$, $\log M_1 = 4.83668$ and $\log N_1 = 6.86521-10$; and these last two, together with the gun, projectile and charge constants, substituted in equations (39) and (40) of Chapter IV, give the following very simple expressions for the velocity of the projectile at any point within the bore, and the corresponding pressure on its base, namely,

$$v^2 = [6.20356]\, X_1 \left\{ 1-[8.59381-10]\, X_0 \right\} \quad . \; . \; . \; (41)$$

and

$$p = [4.72060]\, X_2 \left\{ 1-[8.59381-10]\, X_3 \right\} \quad . \; . \; . \; (42)$$

The quantities X_0, X_1, X_2 and X_3 it will be remembered, are functions of x (or u/z_0) and can be taken (or rather their logarithms) directly from Table II, for any assumed value of the argument x.‡ The corresponding distance traveled by the projectile is

* See Benét's memoir, originally published in the *Journal of the U.S. Artillery*, Volume I, July, 1892. Also Volume 2, page 85.

† *Memorial de l'Artillere de la Marine*, 1892. Also Ord. Con. Note, No. 62, May 31, 1893.

‡ Also see *Journal of U.S. Artillery*, Volume 3, January, 1894.

$$u = xz_0 \quad \ldots\ldots\ldots\ldots \quad (43)$$

Equation (42) gives the pressure per square inch on the base of the projectile, in pounds, in accordance with the general custom; but it will be more convenient for our purpose to change the equation so that it will give the entire pressure on the base, which is the pressure P_t in equation (13), and to avoid large numbers the ton will be taken for the unit of weight. We therefore have

$$P_t = \frac{\pi r^2}{2240} p.$$

This substitution changes equation (42) to

$$P_t = [3.26544]\, X_2 \left\{ 1 - [8.59381 - 10]\, X_3 \right\} \quad \ldots \quad (44)$$

It may be remarked here that in our equations the velocities can be computed in meter-seconds and the pressures in kilos per cm^2 (or in any other units) by suitable changes in the numerical factors outside the brackets, no reductions of the data from one unit to another being necessary.

Finally the mass of the projectile expressed in tons is

$$M = \frac{575}{2240g},$$

therefore $\log M = 7.90210 - 10$.

We have now all the formulas and data necessary for computing the pressure on the lands of the 10-inch B. L. R. fired with the service charge, for the system of rifling actually adopted, or for any other system that may be proposed, with the exceptions of the proper values of μ and f required in equation (13). For the cored shot adopted for our sea-coast guns $\mu = 0.5$, and for shells $\mu = 0.57$. As has been already stated the coefficient of friction for a uniform twist is 0.2; but it is evident that this coefficient is greater for an increasing twist on account of the constantly increasing deformation of the rotating band as the projectile moves along the bore to the muzzle. Experiments have shown that this moulding or shearing of the copper band nearly doubles the coefficient of friction when at its maximum value. We will therefore make for increasing twist,

$$f = 0.2 + 1.5 \tan \theta.$$

The working formulas for computing the pressure on the lands are therefore for cored shot, as follows: For a uniform twist (equation 19),

$$R = 0.065\, P_t,$$

and for the twist adopted for our sea-coast guns (or for any increasing twist) equation (13) becomes

$$R = \tfrac{1}{2} K_1 \left\{ P_t \tan\theta + M v^2 f''(x), \right\}$$

in which

$$K_1 = \frac{\sec\theta}{1-(0.2 + 1.5 \tan\theta)\tan\theta}.$$

In the following table the first column gives the number of volumes of expansion of the powder gases for the distances travelled by the projectile from its firing seat, as given in the second column. The other columns are sufficiently described by their headings:

Pressures on lands required to produce rotation of shot in the 10-inch B. L. R for different systems of rifling. Charge 250 *lbs. Muzzle velocity* 1975 *f. s. Maximum pressure on base of projectile* 33300 *lbs. per square inch.*

Volumes of expansion. (x)	Travel of shot. Feet. (u)	Velocity of shot. f. s. (v)	Pressure on base of shot. Tons. (P_t)	PRESSURE ON LANDS. TONS. Uniform twist.	Twist of army guns. Eq. (20)	Twist of naval guns. Eq. (26)
0.0	0.	0.0	0.0	0.0	0.0	0.0
.1	0.3461	227.7	841.1	54.7	28.6	11.7
.2	0.6922	366.7	1036.4	67.4	37.2	20.8
0.3	1.0382	478.1	1122.4	73.0	42.6	28.2
.4	1.3843	572.4	1158.3	75.3	46.3	34.3
.5	1.7304	654.7	1167.4	75.9	49.0	39.3
0.6	2.0765	727.8	1161.1	75.5	51.1	43.6
.7	2.4226	793.6	1145.6	74.5	52.8	47.2
.8	2.7686	853.4	1124.7	73.1	54.1	50.4
0.9	3.1147	908.2	1100.7	71.5	55.3	53.0
1.0	3.4608	958.7	1075.0	69.9	56.2	55.4
1.1	3.8069	1005.6	1048.5	68.2	57.0	57.5
1.2	4.1530	1049.3	1021.9	66.4	57.7	59.2
1.3	4.4991	1090.2	995.5	64.7	58.3	60.8
1.4	4.8452	1128.6	969.7	63.0	58.8	62.2
1.5	5.1912	1164.7	944.5	61.4	59.2	63.4
1.6	5.5372	1198.9	920.1	59.8	59.6	64.5
1.7	5.8833	1231.4	896.4	58.3	60.0	65.5
1.8	6.2294	1262.1	873.6	56.8	60.3	66.3
1.9	6.5755	1291.4	851.7	55.4	60.5	67.1
2.0	6.9216	1319.4	830.5	54.0	60.7	67.8
3.0	10.3824	1543.4	659.4	42.9	62.1	72.0
4.0	13.8432	1702.8	541.4	35.2	62.2	73.3
5.0	17.3040	1824.9	456.4	29.7	61.9	73.4
6.0	20.7648	1922.8	392.4	25.5	61.2	73.0
6.0671	20.9972	1928.7	388.7	25.3	61.2	72.2
6.6242	22.9250	1975.0	359.9	23.4	23.4	23.4

According to the above theoretical table the maximum pressure on the base of the projectile occurs when the projectile has moved a little more than twenty inches, while for the next foot or more the rapid disengagement of gas due to the great pressure to which the grains are subjected keeps this pressure nearly to the maximum point, notwithstanding the increased volume it occupies. The pressure then diminishes more rapidly, and when the projectile has moved about 3.75 feet, the space-pressure curve changes its curvature from concave to convex toward the axis of abscissas (spaces), this latter being (theoretically) an asymptote to the curve. The pressure at the muzzle is a little less than one-third of its maximum value.

(TO BE CONTINUED.)

Captain JAMES M. INGALLS,
First Artillery.

NOTES ON EUROPEAN SEA-COAST FORTIFICATIONS.

Translated and compiled from the French: *La Défense des Côtes D'Europe, par Carl Didelot.*

GENERAL CONSIDERATIONS ON COAST-DEFENSE.

The attacks to which the coasts of a large country are exposed are of several kinds, more or less dangerous. There are:

1st. *Bombardments,* directed against military ports, or commercial ones, with the heavy artillery with which armored ships are armed to-day; guns of 6".3, 7".4, 9".4, 10".5, 12".5, 13".6 calibers.

2d. *Disembarkments* of troops in large or small numbers, according to the object of the attack.

The means of defense employed are:

1st. The *Navy,* with its battleships, fast cruisers, coast-guard ships and torpedo-boats.

2nd. *Coast batteries,* armored, casemated or open, armed with guns of large caliber (6".3 to 12".5, Armstrong guns of 100 tons, etc.) and forming the fixed defense.

3d. *Torpedoes* and *submarine defenses,* fixed or mobile.

4th. The *mobile land defense* by means of the troops of the active army.

We are concerned more especially with the maritime fortresses of to-day, their defense, their armament. Great changes have taken place in the last few years, in this part of the defense of coasts, and the progress made therein is well worth setting forth.

The permanent fortifications of any fortified port are intended to secure:

1st. The defense of the arsenal, port or city; formerly very important, but now altogether subordinate to the success of the exterior defense.

2d. The defense of the harbor and its channels.

3d. The defense, from the land side, of exterior positions which command the place, or of those which command access to it.

We shall consider only those of the second group, which are of more interest than those of the first, and are of more importance to us than those of the third.

The defense of a harbor and its channels naturally does not admit of continuous lines of fortifications. It consists of *forts*, isolated works completely closed; and of *batteries*, works armed only on the side toward the sea, and if not entirely open at the gorge, at least protected on that side only by secondary defenses.

We will give here a brief description of the coast-batteries and forts, so that when mention is made of them, a clear idea will be had of what is implied.

COAST BATTERIES.—Considering the construction of these works and the disposition of their artillery, it is best to adopt the two following classes: (1) casemated batteries, and (2) barbette batteries (with or without armored turrets).

1st. *Casemated batteries.*—The arch is formed, in general, of solid masonry about 3 feet in thickness, covered with 13 to 15 feet of earth. These batteries are generally surmounted by a barbette battery, forming in this case, batteries of two tiers of fire. Shields on mantlets made of metallic plates of great resistance are used for the protection of the embrasures, and the latter have been reduced to the minimum size compatible with aiming. Many casemated batteries have a simple mask for the embrasures made of rope or wood.

2d. *Barbette batteries (without armored turrets).*—These batteries are the most numerous. They possess many advantages as regards the firing of their guns, but the protection of the pieces and cannoneers is rendered difficult. They are of earth, and great thickness and solidity is given to the epaulments and traverses. The interiors of the latter are used for the magazines, etc., and shelters for the men. A bomb-proof redoubt serves to lodge the infantry garrison charged with the defense of the gorge of the work.

Armored batteries are either casemated, or of the revolving turret kind, or of two stories: casemates and turrets. The Grüson system is familiar to all. In this we find casemated works formed of a series of plates of double curvature, open to the rear, as a rule; the roof horizontal and supported in rear of the pieces by strong masonry pillars. The thickness of the plates is very variable; it is a maximum at the embrasure (27.3, 31.2 and even 32.7 inches in some cases) diminishing to 14.8 or 15.6 inches. The roof does not exceed 13.6 inches in thickness, and generally is about 7.8 to 9.7 inehes.

When thought necessary, these casemates are surmounted by one or more revolving cupola-turrets of the same system. As the name implies, these are simply revolving turrets on which

rest the cupolas. The embrasure is very narrow, as in the armored batteries, and the sighting is done from the exterior. The turret is protected by a glacis made of plates of the same system.

FORTS.—These are of two classes: (*a*) those built on the land or an island, and (*b*) those (sometimes called sea-forts) built on sand-banks or bars, the foundations at the level of the sea, or ordinarily submerged by water.

The first kind approach closely the continental land forts in both type and trace, only they are more substantially built. In some the bastioned trace has been preserved, only the salients of the bastions being provided with armored revolving turrets; others, on the contrary, are designed to receive only turrets.

The oldest examples of the sea-forts are those of England along the channel. They are built largely of granite, armored. Armor of the sandwich system as at Portsmouth and Plymouth, or of the Grüson system as on the Elbe. Some of these forts have cupolas, others have not.

We shall consider now the coasts of the great foreign powers, their system of defense as a whole, and the defenses of the principal fortified places along their coasts.

ENGLAND.

(*a*) *Organization.*—England, like France, has a mixed organization for the defense of her coasts, dividing it, as she does, between the army and the navy. While the Admiralty is responsible for the military ports, and the mobile defenses by means of vessels of every kind, the War Office has charge of the forts and coast batteries, and also of the lines of torpedoes.

For the instruction in time of peace and the mobilization in time of war of the naval personnel, the coasts of the United Kingdom are divided into nine districts: five in England, two in Scotland and two in Ireland. No one post has been chosen as headquarters. Each district is divided into divisions (73), and each division into stations (230). The districts are commanded by captains in the navy under the rear admiral, superintendent of reserves, who is chief of the whole service under the direct orders of the Admiralty. The divisions are under the orders of inspectors with rank of commander or lieutenant; the stations are directed by warrant officers.

An important modification has been made in the organization for coast-defense, February, 1893. The Royal Naval Artillery Volunteers, a corps that serve in the coast batteries or on the

vessels having charge of the defense of the coasts, have been suppressed. Created in 1873, it comprised about 2,000 men. It is to be presumed that it is to be shortly reorganized under another name, losing its character of volunteer troops, and to be put completely in the hands of the War Office.

To each of the nine districts is attached a district-ship with a reduced crew, commanded by the captain who is chief of the district. These ships complete their crews from the men of the reserve at a fixed time every year, and for a certain period, and unite in a squadron for practice in battle exercises and evolutions. In case of war, their crews composed of men living in the neighborhood immediately join each their ship; and the aggregate from all these ships furnishes a disposable force at the very beginning of hostilities. In addition to these, many small vessels, numerous torpedo-boats and finally the channel squadron are permanently on or near the English coasts.

The district ships aside, the three important commands, Portsmouth, Plymouth and Sheerness, should suffice of themselves for the mobile defense of their sea-coast. At Portsmouth there are 1 armored ship, 11 gunboats and 18 torpedo-boats. At Plymouth 2 armored ships, 8 gunboats, 14 torpedo-boats. At Sheerness 2 gunboats, 8 torpedo-boats.

(*b*) Artillery and coast-defenses:—

The artillery of the English coasts consists of muzzle-loading and breech-loading cannon; the latter, the construction of which is being actively pushed at Woolwich, are destined to replace the former which still form the larger part of the armament. The pieces most usually met with are given in the following table:

Model.	Caliber.	Weight.		I. V. f. s.	Make.
		Gun in tons.	Projectile. lbs.		
Breech-loading (new model)	6″	4.1	100	1900	Woolwich
Same	12-pdr (7 cwt)	.36	12.4	1695	"
Breech-loading (old model)	7″ (82 cwt)	4.17	110.	1085	Armstrong
Same	40-pdr (35cwt)	1.78	41.2	1170	"
Same	12-pdr (8 cwt)	.41	11.2	1224	"
Muzzle-loading	17″.72	101.6	1960	1540	"
"	16″	81.3	1680	1575	Woolwich
"	12″	36.	705	1375	"
"	10″	18.4	405	1365	"
"	9″	12.2	174	1370	"
"	7″	7.1	112	1547	"
"	64-pdr (71 cwt)	3.6	64	1115	"
"	9-pdr (6 cwt)	.305	9	1375	"

England has 920 heavy guns mounted on her coasts, but none can be pointed with more than 10° elevation, which limits the maximum range to about 4,572 m (4953 yds.). The 38-ton guns (32 cm. 12".5) are in casemated batteries, where more than 7° elevation is almost everywhere impossible, which reduces the range to 4114 m (4457 yds.). To remedy this state of affairs, an improved carriage has recently been invented, which, used with the 23 cm. (9") guns in Fort Warden, Isle of Wight, has made it possible to obtain a range of 9143 m. (9905 yds.) and depression sufficient to reach vessels passing at short distances from the elevated batteries.

The largest English pieces are the four 100-ton guns at Malta and Gibralter. Then come the two 80-ton guns in the Dover battery. Besides these six guns, the main part of the armament consists of 9", 10", 11", 12" and 12".5 guns.

At Woolwich, steel breech-loading cannon (French fermeture) are being constructed, of 9".2, 10" and 12" caliber, which will replace gradually the preceding. The English also have rifled howitzers or mortars of 9" and 10" caliber, muzzle loading. The mounting of these new guns will extraordinarily increase the value of the English fortresses.

A 38 cm. (15") pneumatic gun, ordered from the U. S. by the Admiralty, is being tried at Shoeburyness.

The War Office, charged with the fixed defenses by means of torpedoes, has under its orders six corps of "Volunteer Submarine Miners." The defense of the estuaries, Falmouth, the Tay, the Humber, the Tees, the Forth and the Severn, is the special destination of these corps. There are two stations for the Brennan dirigible torpedoes, one at Sheerness and one at Plymouth. The automobile torpedo adopted is the Whitehead.

The types of works in existence in England's maritime defenses, may be placed roughly in three classes :

1st. Casemated masonry forts with iron shields.

2d. Casemated batteries with continuous iron front.

3d. Earthen barbette or disappearing-gun batteries, for guns mounted on overbank or disappearing carriages.

Every emplacement being built is of the third class. Where the sites are low and breech-loading guns are provided, it is combined with a disappearing mounting.

(*c*) Special considerations :—

The most important part of the English coast is that along the channel. It seems expressly made for a great maritime power ; hence it is along this coast that England has accumulated her

arsenals, fortifications and means of offense or defense. In a length of 400 km. (250 miles), there are no less than eight ports or fortified harbors that might serve as bases or places of refuge for her fleets.

The principal fortified places along the coast are Plymouth, Portland, Portsmouth, Dover, Sheerness, Liverpool and Pembroke. London, itself, although not fortified, is protected by some exterior works and two exterior lines of defense.

PLYMOUTH.—The first group of fortifications, those of the cities of Plymouth, Stonehouse and Davenport, are old bastioned works and redoubts with guns mounted in barbette.

The second group, those of the harbor and sound, comprise the following works:

Fort Breakwater. This is an elliptical work (longer axis parallel to the breakwater), entirely armored and has numerous casemates. It mounts 18 pieces of large caliber: four of 18 tons (10″) and 14 of 38 tons (12″.5) Woolwich muzzle-loading guns.

The new battery of Whitsand Bay, west of the Sound, is not yet armed. It is to receive two muzzle-loading guns of 38 tons (12″.5, Woolwich) and three breech-loading guns of 42 tons.

Fort Picklecombe is a granite structure with two tiers of casemates, armed with 42 guns: 4 of 7 tons, 19 of 12 (9″) and 19 of 18 (10″). All the masonry, arches included, is of granite and 6 m. thick. The embrasures are protected by metallic masks made of three plates of wrought-iron, 12 cm. thick, and two layers of teak-wood 12 cm. thick, sandwiched in between, separating the iron ones.

Fort Cawsand. This is a circular work armed with ten guns of 18 tons (10″).

Mount Edgecombe Battery, or the Garden Battery, is a small casemated battery mounting seven guns.

The Western King battery, armed with nine guns of large caliber.

The Eastern King battery, seven pieces.

The batteries of St. Nicholas or Drake Island, are of considerable importance in defense of the entrance of the port; hence they have been considerably enlarged and strengthened within recent years. They consist of a granite fort, similar to Fort Picklecombe, for 21 guns, at an altitude of 13 m.; and the barbette battery (alt. 23 m.) for nine pieces of 12 tons.

Continuing around to the East, we come to Fort Stamford (alt. 55 m.). It mounts 7 pieces for the defense of the port, and 13 pieces and 6 mortars for the land defense.

Fort Staddon is a large work of earth. It has revetted ditches 17 m. wide, 10 m. deep, and casemated emplacements for 34 guns of large caliber. The ditch is extended to the south west about 700 m.; along it there is:

Brownhill Battery, a pentagonal earthen work for 14 guns;

Watch-house Brake Battery for five guns;

The Old Staddon-Point Battery, seven guns, with a weak parapet of stone.

Fort Bovisand is a semi-elliptical granite work, one tier of casemates, mounting 23 guns of 18 and 22 tons.

The third group of fortifications consists of Forts Polhawn, Tregantle and Screadson, and the works on the west of the Tamar. These are old works and redoubts, muzzle loading guns.

The fourth group is the land forts between the Tamar and the Plym. Fort Crownhill is the key of the position. They are armed with heavy guns and mortars.

Batteries Penlee and Raleigh are new works now almost finished.

PORTSMOUTH.—This is a military port and a fortified place of the first order, one of the best of Europe. Its fortifications are vast in extent, and the defensive system of the city and its environs is rather complex. The works are mostly of old design and construction, but of late years, strengthened and remodeled.

There is an enceinte, an old bastioned work; and several adjacent works, of granite and earth, with casemated guns.

Along the sea-coast, there is: Fort Monkton, and important battery of 40 pieces, 20 casemated and 20 on the ramparts.

The Gilkicker Battery. This is a new fort of granite. It mounts 27 guns, 9″ and 12″ caliber. Four 9″ guns are in an armored battery, and three 12″ guns are mounted on tne rampart behind a parapet 10 m. thick, and fired through embrasures therein; twenty 9″ guns are casemated; embrasures protected by the usual sandwich masks.

Southsea-castle has an armament of 52 guns: two armored batteries 32 pieces, and a mortar battery in rear of eight mortars, 9″ caliber.

Fort Lumps, besides its 14 guns firing through embrasures, has in each of the three salients towards the sea, a cavalier carrying one gun on center-pintle carriage, barbette fire, thus permitting fire in all directions.

Fort Cumberland is a newly constructed bastioned work for 80 guns. It is armed with 6″ breech-loading cannon.

To défend the harbor and prevent the bombardment of Portsmouth by sea, four large armored forts of circular form have been constructed, named Spitsand, Horse-Sand, Noman-Sand and St. Helen. They were finished in 1877. The two most important ones are Horse and Noman. These armored towers, resting on the granite masonry foundation, are 29 m. in diameter, and have two tiers of casemates, armed with twenty-five 9″ guns and twenty-five 10″ guns, Woolwich muzzle-loading. Recently there were to be installed on the upper platform, five revolving turrets each armed with 12″ guns. "Under these conditions, it must be seen that these would be formidable adversaries for an armored fleet. Nevertheless their walls would be easily pierced by modern cannon."

It is in reference to these works at Spithead that Sir William Armstrong said: a large number of our armored forts are robbed to-day of their defensive value, considering the progress that artillery has made since their creation. "On the other hand, their offensive value has been increased by increasing the caliber of the pieces under casemates. Forts Horse and Noman have now guns of 11″ caliber in their lower battery; but it has been necessary, for want of space, to use all the resources of hydraulic power to insure the proper service of the new materiel. Hence it results from this, that instead of entrusting the defense of these forts to cannoneers drawn from the naval reserves or from the volunteers, a select personnel will be employed perfectly familiar with their duties and the care which these delicate engines require" (Degouy).

Spitsand (60 m. diameter) has 15 heavy guns, 10 of 38 tons (12″.5).

Horse-Sand (80 m. diameter) mounts 50 guns: 9″ and 12″, augmented by ten of 30.5 cm. caliber (12″) in five revolving turrets on top.

Noman-Sand, the same.

Fort St. Helen, 15 guns (two 10″ and two 12″.5) in armored batteries, and two turrets for two pieces each.

The Puckpool battery is an earthen work for 30 mortars and 4 heavy guns, of which two are of 30.5 cm. caliber, 47 tons.

The Needles is defended by nine works all armed with heavy guns of from 12 to 38 tons weight, 9″, 10″ and 12″.5 caliber, firing some in casemates, some in barbette.

Fort Sandown is the most important work on the Isle of Wight. Besides the 20 guns in casemates, eight of 18 tons (9″) are to fire

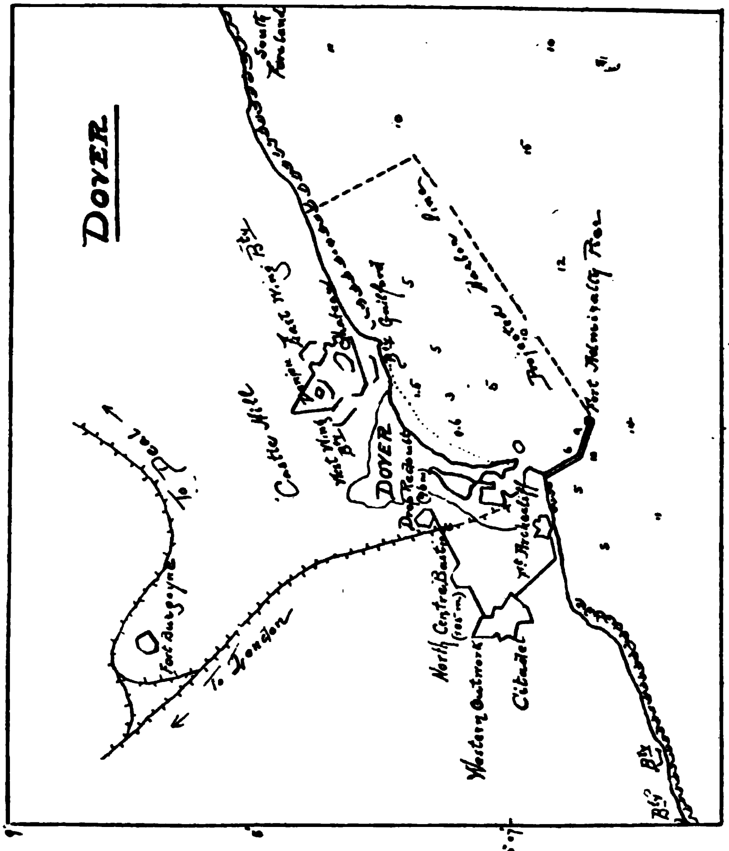
ounted on

ortsmouth,
that side.
ament con-
103 Arm-
6″ and 8″
es.

lefense are
ned for six
al batteries
ant work is
ted at the
iding guns
the largest

from the platform above (earthen parapet in front) mounted on Moncrieff disappearing carriages.

There is a cordon of land forts to the north of Portsmouth, along the line of Portsdown hill, for its defense from that side. Six large works constitute the main line. Their armament consists of about 200 heavy guns and mortars, of which 103 Armstrong guns of 7″ and 8″ caliber, and 28 mortars of 6″ and 8″ caliber form the armament of the intermediate batteries.

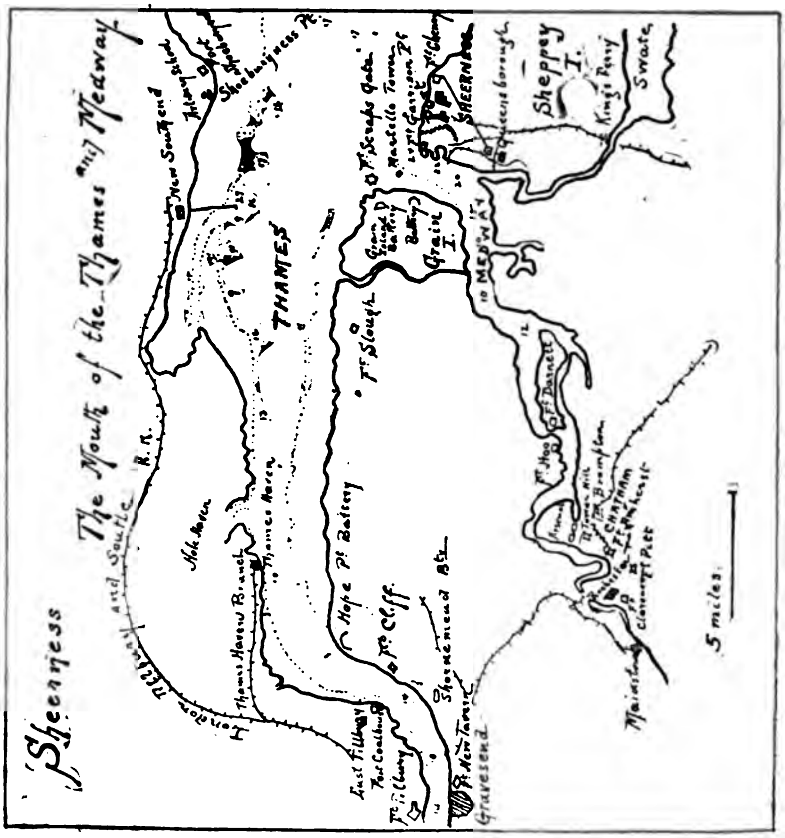


Dover.—The most recent works for its sea-coast defense are Fort Archcliffe, completely remodeled in 1881, designed for six guns of 23 tons; and the defenses of the jetty, several batteries of recent construction, but of which the most important work is the massive armored cupola of Grüson model, situated at the extremity of the jetty. Two 80-ton (16″) muzzle-loading guns arm this cupola. Up to the present time, these are the largest

guns that fire under an armored cupola, the 100-ton guns of Malta, Gibraltar and Spezia, firing in barbette behind ordinary earthen parapets. The vertical field of fire is from $+7°$ to $-2°$. A glacis revetted with plates (7 to 12 cm. in thickness) surrounds the cupola, and under cover of this the pieces can be served and loaded. Dover is the only English port defended by an armored cupola, and yet the fire of its pieces would be much too slow.

SHEERNESS.—The works for the defense of this important city consist of a bastioned enceinte, the advanced line of Queensborough, all earthen works.

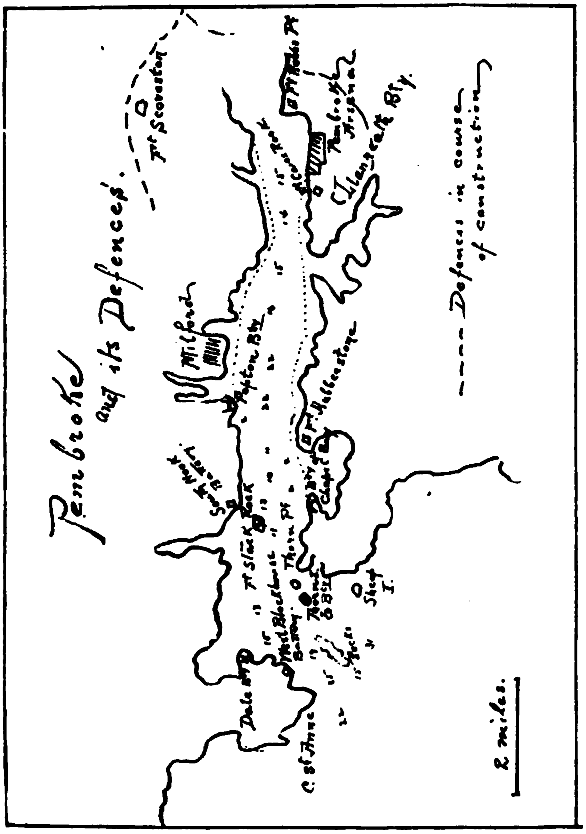
Fort Garrison-Point, built of granite, two tiers of armored casemates. This work, the most important of the whole group, has 19 guns in its lower battery, 17 above; three 12", three 11", ten 10" and twenty 9". It has, besides, two armored turrets, each armed with two guns (6 cwt.). This fort might be considered as the type adopted in England for the larger number of



the granite forts built in recent times for the defense of her coasts and ports.

There are two batteries on Grain Island, and between Sheerness and Chatham, the two circular granite forts, Darnett and Hoo, 7″ and 9″ guns. At Scrap's Gate near Sheerness, there has been built (1890) a new fort of earth. It is armed with two steel breech-loading guns of 10″ caliber (30-ton), and two breech-loading guns, steel, of 6″ caliber (5-ton). As Fort Garrison-Point and the other batteries of Sheerness are actually armed with only muzzle loading guns (except some pieces of small caliber) this fort is an important addition to the defenses of the Thames and Medway.

London.—The exterior works for its defense are those on Grain Island, Fort Slough, a new battery near this fort (25-ton guns), a new fort on Barton's Point, four 10″ breech-loading guns, steel, and Fort Shoeburyness. The first line of defense



includes Fort Cliff, Fort Shorne-Mead, Fort Coalhouse, granite forts, guns casemated and in barbette, 12",5, 11" calibers.

Second line: Forts New-Tavern and Tillbury, the latter an important work. Guns of 9" caliber.

LIVERPOOL.—The mouth of the Mersey is defended by numerous works constructed in recent years. Batteries of earth, guns 12" 12".5 calibers.

PEMBROKE.—This important arsenal is protected by three batteries along the north shore, one on Thorn Island mounting about 30 guns, 10" caliber; the two batteries of South Hook; Fort Stack-Rock, granite; and Chapel Bay battery, 10" guns.

The works of the interior defense are all old and of little value; but about five miles to the south-west of Pembroke, there is Fresh water East battery, a new work, solidly built of earth, mounting 12 guns.

(TO BE CONTINUED.)

Lieutenant ANDREW HERO, JR.,
Fourth Artillery,

THE BICYCLE AND ITS ADAPTABILITY TO MILITARY PURPOSES.

(Continued from the March-April *Journal*, Vol. V, No. 2).

PART II. THE MILITARY BICYCLE.

Up to the present time we have discussed the bicycle from the popular standpoint; it now remains to consider its utility for military purposes, and what modifications of construction, if any, this special use might reasonably entail.

From the day when Lallement's "bone shaker" demonstrated that a new means of locomotion was at hand, keen-sighted military men have not failed to realize that this invention might have an important bearing on the "game of war". As early as 1875, in Italy, in the maneuvers about Somma, a regular service of cyclists was established for carrying despatches, proving so successful that thenceforward the military cyclist has been continually employed in that country for this purpose. This example has been followed by that of other countries, until, at the present time, the bicycle is recognized as a portion of the military equipment of every European army, though the number employed and the precise rôle it is to fill seem as yet nowhere definitely settled. It is not to be wondered at, that there should be much difference of opinion as to the exact nature of the duties that the cyclist should and can perform, since it is manifest that these duties depend for their fulfillment, not only upon the intelligence and physique of the rider, but also upon the mechanical capabilities and limitations of his mount, which, as we have seen, have until quite recently been affected by the great improvements that each year has brought forth in the wheel. Let us then at the outset inquire into what are the chief requisites for a military cycle, and let us see how nearly those requisites can be obtained; for it is evident that by such an investigation alone may we arrive at just conclusions as to the expedient uses to which the military wheel can be put. These requisites we shall discuss in the following order:

1. *Sufficient Strength with Minimum Weight.*—It is hardly necessary to say that the military bicycle will be put to harder work, and will necessarily undergo more severe strains than is the case with the commercial wheel of civil life. The tourist is ordinarily

free to select his route; chooses the best roads; travels only in fair weather; reduces his speed, or even dismounts and walks, to ease his machine over an obstacle or temporary stretch of bad road; and has the choice of the entire roadway from which to select the path that is best and easiest on himself and wheel; in fine, is perfectly unhampered. The military conditions are far less elastic. The main roads may be choked with trains and troops that could scarcely make way, even if they had the disposition, for a body of cyclists; and it must be expected that the great and unusually heavy traffic over them, incident to a time of war, will cut them up and render them still less like "ideal bicycle roads." Indifferent or bad country roads, abounding in stones, gullies, and other obstacles, or heavy with sand, will have to be traversed, as will likewise roads that are usually good, but rendered bad by heavy rains. Moreover, if military wheelmen are to act together in any number, it will usually be necessary for them to preserve a certain uniformity of speed, and to ride in as close and compact an order as possible, so that the column may not be unduly extended, or its march retarded. We shall discuss hereafter the tactical considerations herein involved; for the present it is sufficient to recognize the fact that they exist, and the military wheel, if it is ever to obtain more than a moderate degree of success, must be built to conform to them. This will require, wherever practicable, that the whole road surface shall be utilized, and will allow but slight, if any, diminution in speed for small obstacles for which the ordinary rider would materially check his gait.

It is a well known fact that engineers usually allow a factor of safety of from 5 to 8 in passing from a static to a moving load; but according to a recent authority,* the factor of safety of the modern light roadster is less than 2; indeed, as low as 1.25 for a 20-pound machine. *Careful* riders on good roads may find a wheel of this weight sufficiently strong, but for the average wheelman it is doubtful if the manufacturer in catering to the demand for a light wheel, has not gone too far in the matter of weight reduction.†

* Mr. Cleveland Moffett, in "McClure's Magazine."

† A writer in a recent number of the New York *Sun* commenting on this subject under the heading "Better Wheels, Not Lower Prices Wanted," remarks as follows:

"The present high-grade wheels are defective in strength. In the foolish race for lightness the manufacturers have passed the limit of safety. The really high-grade wheel is very fair for a rider who weighs under 130 pounds: if the rider is over 150 or 160 pounds in weight things keep going like overtuned fiddle strings. The crowded state of the repair shops is a matter for the serious consideration of every manufacturer of wheels who wants a reputation for giving thorough satisfaction to his customers.

I have purchased three wheels of a make that all concede to be first class. One bought two months ago has been 'in the hospital' two weeks to a day, all counted."

It is indeed highly desirable to keep down the weight of the military bicycle to the lowest notch, just as it is desirable to reduce all *impedimenta*. But the same reasons that exact that the soldier's shoes shall be heavier than the civilian's; that his musket be sheathed, and made stronger and heavier than the sporting rifle; and that all manner of military conveyances be greatly reinforced over and above what would be demanded of vehicles intended for the same loads in time of peace,—also exact that the military bicycle shall be made stancher than the commercial wheel. I know there are those who advocate for military use an extremely light wheel, principally on the ground of its greater mobility; but this I think is a mistake. We must have a wheel sufficiently strong to make its breaking down highly improbable, not only with good treatment, but even when handled roughly. We hear a great deal about the bicycle being "frail" and "weak;" but why should it be? The form of its frame is admittedly one suitable to great rigidity and strength; the material that enters it equals or surpasses in toughness, elasticity and ultimate strength that employed in any other structure; and the mechanical execution of its assemblement is of the highest order. Granted that the present light road wheel is too "frail" to be of use as a military machine, it does not follow, as some military critics would have us believe, that no military bicycle can ever be of much use. By the addition of a few pounds of steel we may increase the strength of our bicycle frame to any extent desired, nor will we greatly augment the amount of work to be done in driving it. Practically, it is thought that a military wheel can be made to stand up perfectly under its burden of the rider and his equipment, at a minimum weight of from 32 to 33 pounds.*

The strength, efficiency and value of a military cycle will be largely dependent upon the selection of a proper tire and rim. The wood rim is probably the weakest part of the commercial wheel; but being lighter than the steel rim, and possessing within the limit of its strength greater flexibility, it reduces vibration, and has permitted the use of tires of smaller diameter, with an additional reduction of weight on this account. While with careful riding on good roads it answers every purpose, it is easily crushed in and broken when put to more severe tests. This very weakness is, however, for most riders more often advan-

* This is the opinion of one of the leading bicycle and military fire-arm manufacturers in this country. My own experience with a wheel weighing about three pounds more than the one suggested, with which I have covered over 15,000 miles of road (much of it in a mountainous country on roads of the roughest sort) with never a broken frame or other serious accident, confirms me in the opinion stated.

tageous than otherwise, since, in case of accident, the rim, which is the most inexpensive and most easily replaceable of the primary parts of the machine, breaks, and thus saves the more expensive parts from serious harm; but it is evident that this consideration has no value from a military standpoint, since the mending of a wheel crippled with a broken rim would be rarely undertaken in the field.*

The metal rim is therefore a necessity for the military cycle, and it is thought that a hollow rim of mild steel with *drilled* holes for the spokes, and reinforced with a light washer (to give a greater bearing surface) at the point where each spoke leads from it, will be found most strong, light, and generally satisfactory. I can say from experience that such a rim will stand a great deal of deformation without breaking, and can at any time be readily hammered back into shape. This, however, will not often be necessary, if the machine is equipped with suitable tires; but the possession of the quality named, nevertheless, lends additional value to the steel rimmed cycle.

The question of the proper tire for the military bicycle is one that has often been debated. We can say that up to the present time the matter is yet in dispute. It is my own belief that the pneumatic tire, properly designed for the military service, will be found far superior to any other, since not only does it greatly lessen vibration and conduce to the rider's comfort and ability to ride over rough ground, but it also provides the machine with a buffer against sudden blows, and thus permits a great reduction in the machine's weight. We have already discussed (in Part 1) this matter in a general way; but it is perhaps the most important of all in the design of a military wheel, and we propose here to enter into the subject a little more in detail.

Let us suppose that a bicycle, driven along at a good rate, encounters an unexpected obstruction, such as a small pole lying athwart the road. If it is a solid rubber or cushion tire, in reacting, it transmits the force of the shock directly to the adjacent portion of the rim, and the blow is therefore entirely local and concentrated in its effects upon the wheel. With the pneumatic tire, on the contrary, the diminished air volume due to the compression of the tire serves simply to increase almost instantly the pressure throughout, so that the effect of the blow is uniformly distributed, and every point of the rim bears its due

* Another serious objection to the wood rim, in a military wheel, is the fact that it is affected by changes in the state of the weather, season-checking and shrinking in a dry climate; and then, if ridden in the rain, or taken to a damp climate, swelling and warping badly, and twisting the wheel out of shape.

share. The action of the tire, moreover, is that of an elastic buffer or cushion, so that the shock is not felt at once to its fullest intensity, but is distributed gradually during a short but appreciable time, affording an opportunity for the molecular forces to act, and thus permitting the calling into play of every part of the frame of the machine to withstand the blow. Now if the wheel mounts the obstruction without the tire being completely pressed in upon the rim,—that is, before the "cushion power" of the tire (as we shall speak of it hereafter) is exceeded,—it receives no harm, but if the cushion power of the tire is exceeded, the tire is crushed in upon the rim, which receives the balance of the shock as a direct blow, localized at this point, and suffers in consequence more or less serious deformation. If the shock were severe enough, a wooden rim might be broken,—or a metal one badly distorted, while at the same time the frame (fork) would receive a severe strain.

It will appear from a moment's consideration that the effect of such an obstruction upon the bicycle will depend upon the diameter of the wheel, the dimensions and nature of the obstruction, the cushion power of the tire, the weight of the machine and its burden, and the velocity at which it moves.

The diameter of the wheel is fixed within narrow limits by practical considerations, and the only other one of these variables embodied in the construction of the machine is that of the tire or cushion.

The measure of the cushion power of the tire, with respect to any given obstruction, is evidently the work done by that obstruction in crushing the tire into the rim against the elastic pressure of the confined air. Or if we denote this work by C; the internal air pressure, per unit area by p; and the volume displaced by the obstruction by v; we have, as the expression for the cushion power of the tire: $C = \int p.\, dv.$

Since, however, the air volume displaced will always be very small, as compared with the total volume of confined air (probably never exceeding one-fiftieth of the volume of the tire), the variation in pressure is so slight that we may without appreciable error consider p constant; and the formula thus reduces to $C = p.\, v.$

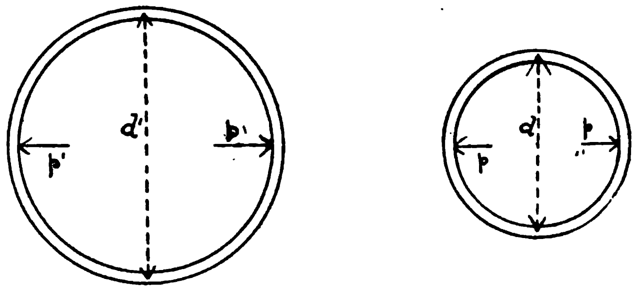
That is, the cushion power of the tire varies directly with the pressure, p, at which the tire is inflated and with the volume, v,

of air which it is possible for the obstruction under consideration to displace.

Considering now several tires of different cross sections, but similar in all other respects, each acted upon and crushed in successively by the same obstruction, it is plain that the air volumes displaced will depend upon the relative sectional areas and may be expressed as a function of some power of the tires' cross-sectional diameters. If the volumes were similar, they would vary with the cubes of the diameters; if on the other hand they resembled cylinders, cut out by two transverse parallel planes, the volumes would vary with the squares of the cross-sectional diameters. Owing to the stiffness of the containing envelope, it is probable that no constant power of the diameter expresses the law for all cases, but it would appear that this power will vary somewhere between the cube and square, the latter being the inferior limit. Assuming, then, as the least favorable case, that the air volumes displaced will vary as the squares of the sectional diameters, let us compare two tires made for the same wheel, from fabric of the same nature and thickness.

Let d and d' denote their respective *mean* cross-sectional diameters; p and p' their respective air pressures per unit of area; C and C' their respective cushion powers; K and K' their respective weights; E and E' their respective bursting efforts, tending to produce rupture along a longitudinal element.

Then it will be evident, from what precedes and from the consideration of the diagrams representing their respective cross sections, that we may write the following approximate relations:



$$\frac{K}{K'} = \frac{\pi d}{\pi d'} = \frac{d}{d'}$$

$$\frac{E}{E'} = \frac{pd}{p'd'}$$

$$\frac{C}{C'} = \frac{pv}{p'v'} = \frac{pd^2}{p'd'^2}$$

Assuming the pressures equal, that is $p = p'$, it follows directly from the above relations that while the cushion power of the tire (and hence the capability of the machine to withstand sudden shocks encountered on the road) increases, at the least, as the square of the cross-sectional diameter, the weight of the tire, and the effort tending to burst it, increase only as the first power of the diameter. This then affords us a method of increasing, within certain limits, the strength of the bicycle without a corresponding increase in its weight.

If the two diagrams represent, respectively, the present standard road tire of most makers, 1″ 5/8 diameter, and a proposed tire, 2″ 1/2 diameter, we have from the formulas given above:

Ratio of cushion powers of these two tires is 1 : 2.367.

Ratio of their weights is 1 : 1.538.

That is, while the weight of T_1 is but about 54% greater than that of T_2, its cushion power is over 136% greater.

It is proper to remark that this reasoning would be erroneous, were it found necessary to increase the thickness of the fabric of the tire in proportion as the bursting effort is increased; as a matter of fact, however, within the limits available for bicycle construction, any road tire that is made sufficiently thick to have good wearing qualities, will have ample strength to resist the bursting effort of the confined air; it will not, therefore, be necessary to increase the thickness and weight of the tire on this account.

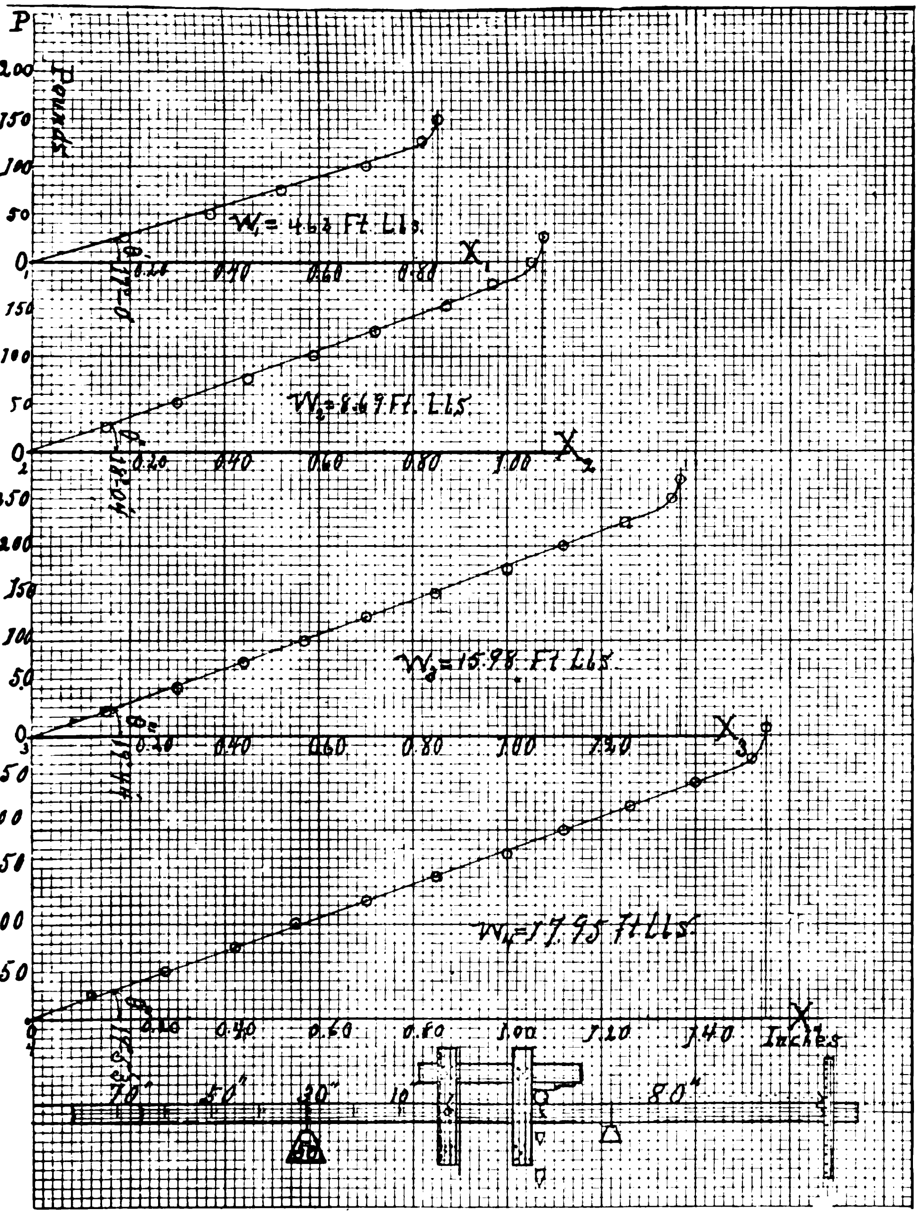
The above discussion has been made on the supposition that the road pressures are the same in each case; but a higher pressure is permissible, on rough roads, in the larger tire; for if in a small tire we employ too high a pressure, the reactions in passing over inequalities in the road surface, such as, for instance, a badly laid granite pavement, are so sudden that the machine is thrown into a very rapid state of vibration, and in extreme cases becomes entirely unridable; on the other hand, if we employ a relatively low pressure in such a tire, the inequalities continually bring up against the rim with severe thumps, rendering such riding very hard upon both the rider and the machine. The greater air volume of the larger tire mitigates this vibratory action, while its wider tread finds more points of support upon the ground, and thus contributes to the same end. Thus it is possible to employ a relatively high pressure, and still ride over rough ground with comparative ease. With a 2″ 1/2 tire properly inflated it should be perfectly feasible to ride over the roughest pavements without injury to the rim or frame of the bicycle.

Experimental verification.—To determine experimentally the relative cushion powers of tires of different diameters, the apparatus shown at the bottom of the subjoined plate, was devised. It consisted of two pairs of vertical uprights, between which (upon a fulcrum supported by one of the pair) a long, stiff lever of wood, 2″ x 4″, was free to revolve. Just above the lever, and securely fastened to the uprights, was a stationary piece of wood, also 2″ x 4″, underneath the projecting end of which was secured a "crusher" for deforming the tires.

Five sets of heavy road tires, ranging in diameters from 2″⅛ to 1″½, were kindly furnished by the manufacturers, Messrs. Morgan & Wright, Chicago, for the experiments. These tires were all provided with the quick repair inner tubes, mentioned in Part 1 of this article, and four of the sets were of their brand known as "the cactus,"—a practically puncture-proof tire, and one that would seem, from its all around qualities, to be admirably adapted to needs of a military bicycle. On this account these tires were selected for the experiments.

The tires were all inflated from an air chamber connected with a force pump, and the pressures were made the same in each, as determined by the reading of a pressure gauge attached to the air chamber. Riding pressures, varying from 50 to 30 pounds per square inch, were used. Each inflated tire was then in succession placed on the section of a rim, and slipped over the short arm of the lever, immediately under the "crusher," and at a point just 20″ from the fulcrum of the lever. The counterpoise weight was then placed on the short arm, so that the lever was just bordering on motion, and the tire brought up so as to just touch the "crusher." In this position the lever was very nearly horizontal. The scale of the reading rod, placed 80″ from the fulcrum of the lever, was then set at zero. The force applied was a 50-pound standard weight. This weight was placed successively at distances of 10″, 20″, 30″, &c., from the fulcrum, and the corresponding deflections noted on the vertical scale. From these data, the pressures brought to bear upon the tire and the corresponding displacements were easily reckoned and tabulated. The results were then plotted upon cross section paper as shown in the diagram, and a line drawn through the points thus determined. The cushion power of the tires, as measured by the work done in deforming them, was then computed, being evidently the area included between the limiting ordinate, the axis of abscissas and the line connecting the points plotted.

A large number of tests were made upon the tires, using three



[By clerical error W_3 above is given = 15.98 ft. lbs. It should be = 14.27 ft. lbs., as per text.]

sets of "crushers" to represent different kinds of obstacles, and pressures similar to those used in riding, of 50 and 30 pounds respectively in each tire, and taking the mean of several readings. In every case the experiment showed that the cushion power varied with some power of the diameter between the second and third and generally speaking, the smallest tire (1½ inch) showed in this respect to poorest advantage. This was evidently due to two facts; 1st, because the rim took up relatively more space with it than with the larger tires; and 2d, because the comparatively inert fabric of the envelope was greater in proportion to the air volume in this tire than in the others.

We have not room here for a complete discussion of all the experiments; but the accompanying diagrams, showing the result of one test, may, it is hoped, be of interest.

The tires were all inflated to a pressure of 50 pounds per square inch.

The "crusher" used in this case was wedge-shaped—the cross section being in the form of a capital V, and this may perhaps be considered to represent most nearly the shape of the obstructions met in practice that do damage to the rim of the wheel. It will be seen from the diagram that the displacement or deformation of the tire is a linear function of the pressure producing it, and this was true in all the experiments. Near the end, this right line tails out and runs in tangent to the final ordinate; this is evidently as it should be, since here the tire has been completely crushed in upon the rim, and it would require a theoretically infinite force to produce further deformation.

A glance at the diagrams will show that the lines representing the functions all make about the same angles with the axis of abscissas; hence, as is to be expected, the work done varies nearly with the square of the displacements. To determine the law definitely for this particular case we have, making the largest tire our unit of comparison:

Ratios of cushion powers;

$$\frac{W_4}{W_3} = \frac{17.95}{14.27} = 1.258$$

$$\frac{W_4}{W_2} = \frac{17.95}{8.69} = 2.065$$

$$\frac{W_4}{W_1} = \frac{17.95}{4.62} = 3.885$$

Ratios of diameters.—Denoting the diameter of the tires tested by d_1, d_2, &c., and comparing all with the largest tire, we have:

$$\frac{d_4}{d_3} = \frac{2''.171}{2''.002} = 1.084$$

$$\frac{d_4}{d_2} = \frac{2''.171}{1''.635} = 1.327$$

$$\frac{d_4}{d_1} = \frac{2''.171}{1''.323} = 1.641$$

Representing by n_1, n_2, &c., the exponents of the powers to which the diameter-ratios must be raised to equal the ratios of the work done in deforming the corresponding tires,—that is the ratios of their "cushion powers,"—we have:

$$[1.084]^{n1} = 1.258\,;\ \therefore\ n_1 = 2.57$$

$$[1.327]^{n2} = 2.065\,;\ \therefore\ n_2 = 2.56$$

$$[1.641]^{n3} = 3.885\,;\ \therefore\ n_3 = 2.74$$

Ratios of the Weights of the Tires Tested.—Denoting the weights of the tires, in pounds, by K_1, K_2, &c., we have, similarly:

$$\frac{K_4}{K_3} = \frac{3.164}{2.648} = 1.195\,;\quad \frac{K_4}{K_2} = \frac{3.164}{2.352} = 1.345\,;\quad \frac{K_4}{K_1} = \frac{3.164}{2.172} = 1.457$$

Comparing these ratios with the corresponding diameter-ratios, it is seen that the weights of the tires are sensibly proportional to the diameters. It is also seen, as was to be expected, that the weight of the smallest tire is proportionally greater than that of the others.

We may say, then, as a summary of all the experiments, that the conclusions drawn from a theoretical standpoint as to the relative superiority of the large tire seem to be fully borne out.

It is worthy of remark that in spite of the severe treatment to which these tires were necessarily subjected in the course of the experiments, the fabric was not broken nor the tires apparently injured in any respect.

The objections hitherto urged against pneumatic tires for military use,—viz., that they are weak, undurable and liable to be easily punctured,—do not seem to me to be well taken. The strength and wearing qualities of the tire are entirely dependent upon the kind and amount of material that is put in it, and the excellence of the manufacturing process. Because pneumatic tires have hitherto been made thin and weak, in response to the demand for extreme lightness, it does not follow at all that a strong tire can not be made. And by employing a tire of relatively large diameter of cross section, we may make it practically

puncture proof, as strong and durable as we choose, and still preserve without material impairment all of the resiliency and other advantages of the pneumatic tire,—and this too, with only a relatively small increase in the total weight. It is a noteworthy fact that the builders of motor wagons, and other vehicles equipped with pneumatic tires, are beginning to recognize the advantages that large pneumatic tires confer upon their machines.*

The practical limit to the size of the pneumatic tire is determined by the spread of the forks necessary to enclose the wheel, and by the difficulty of securing the tire to the rim, so that when unduly large it will not be rolled off from side pressure, as in going around a curve at considerable speed. For bicycles and tandems this limit would seem to be somewhere between .″.5 and 3″.0; and a tire about 2.5 inches in sectional diameter, would probably best fill the requirements of a military machine.

Briefly stated, the advantages of a large pneumatic tire over the "solid" and "cushion" tires used on nearly all the military bicycles abroad are:

1. It increases the strength of the machine, and allows a large reduction in weight, and makes a portable bicycle possible.

2. It reduces perceptibly the work of propulsion. This is true on any kind of road, but particularly noticeable on roads heavy with sand or dust, where the wide tread of the pneumatic tire prevents the machine from cutting in deep.

3. It greatly reduces vibration, and allows the machine to be ridden over rough pavements, rutted roads, "across country," &c., where a wheel equipped with other tires could not be ridden at all.

4. It is mainly or entirely held in place on the rim by air pressure, and is not liable to come loose and leave the rim, through the softening of the cement by which it is attached, on a hot day, as is the case with other tires.

With the exception of one country, the government military cycles abroad, so far as I have been able to learn, are all epuiqped with the old styles of tires, and their weights range from 45 to 55 pounds. The exception noted is Italy, which has recently adopted a pneumatic tired machine, weighing about 35 pounds.

2. *Durability and Simplicity of Design.*—In the main what we have said concerning the elements conducive to the machine's strength will also apply to the matter of durability. The entire machine

* See article on motor carriages in McClure's Magazine, July, 1896; p. 155.

should be made of selected material, and protected from the elements by a hard, burnt-in enamel, which is both more durable and less conspicuous than nickel or other plating.

The construction of the machine should be simple so that it can be readily cleaned, its gearings protected from mud and dust, and all its wearing parts interchangeable in the field without the aid of special tools other than those that can be carried in a simple tool bag. If no serious accident overtakes it, such a machine should stand from 8,000 to 10,000 miles of service before the bearings become badly worn; the tires should stand from 3,000 to 5,000 miles of road, for the rear wheel, and from 5,000 to 8,000 miles for the front wheel; while the frame should be practically everlasting.

When these distances are compared with those that other vehicles accomplish, it will be seen that the durability of the bicycle does not suffer by the comparison.

3. *Controllability and Dirigibility.*—Probably 90% of the wheels now ridden are equipped with no brake, or at the most are provided with a foot-brake attached to the fork, which is no better than the toe applied directly to the front tire. This will not do for a military machine, which must be at all times thoroughly under the control of the rider, no matter at what speed or on what grade he is riding. This controllability can only be obtained when the feet are on the pedals, to steady and relieve the machine and to back-pedal when necessary, in conjunction with a powerful, direct-acting brake; and the riders must be thoroughly skilled and instructed in its use. The rule must be imperatively established that the machine shall be capable, under all circumstances, of being brought to rest within the distance allowed between it and the wheel immediately preceding; and conversely the minimum distance between wheels must be that within which this can be done. Generally speaking, it should be possible, by the aid of the brake, to bring the machine to a rest anywhere within twice its own length.

The importance of this matter will be appreciated by those who have witnessed a "go-as-you-please" club run of wheelmen, where a single accident, dismounting one rider, may result in the piling up of a dozen more, with their brakeless wheels, in one confused heap. Many fatal accidents have resulted from riders attempting to descend steep hills without a brake, who have lost control of their machines through inability to hold them by back-pedaling alone.

The objection to the brake, besides the additional weight

which it offers, and the vibration of its loose parts, is that it acts on the tire and rapidly wears it away. Various expedients have been tried to overcome this, such as making the brake bear upon the chain, the crank-axle, or upon an auxiliary friction wheel.

But in spite of the objection referred to, I believe that the direct-acting "plunger" brake will be found best for a military wheel. It brings the pressure to bear directly on the periphery of the wheel, and thus gives the greatest lever arm possible to the frictional moment, while at the same time it is simplest in form, and offers the least strain upon the wheel. By making the brake renewable, and of material such that the wear shall be upon it rather than upon the tire, and of such a form that it will bear upon the sides of the tire rather than upon the tread, it would seem that it should be perfectly satisfactory.

The brake should not be used except in case of necessity, but when it is needed, it should be of such a character that its action is *felt*.

The control of the machine is likewise largely dependent upon its steering qualities, or dirigibility. The military cycle should be constructed so that it can be maneuvered in the shortest space possible, and should respond in steering to the slightest touch upon the handle bars, so that the rider may be as nearly independent of his mount and able to give as much attention to other matters as is in the nature of the case possible. The steering qualities of the machines now on the market are usually very good, but in considering any new design of machine intended for the military service, the question of its dirigibility should be carefully examined into.

It should be remarked here that the great length of the tandem, as ordinarily built, and of other multicycles, render them more difficult to manage than the simple wheel.

4. *Ease of Running, and Independence of Road and Weather Conditions.*—The bicycle is valuable from a military as well as from a civilian point of view primarily as by its use we are saved time and work. Wherever the condition of the road is such that the employment of the bicycle materially reduces the work that a soldier must perform in moving from place to place, or reduces the time necessary for such a march, its employment is proper, if it does not interfere with other essential military considerations. But where the bicycle does not result in such material gain in labor or time, it becomes simply so much dead weight upon its

rider. The work done, then, by the bicyclist in propelling his machine becomes an important matter for consideration.

Captain J. Paloque, French Artillery, in an able article in a recent number of the *Revue d' Artillerie*,* has made a critical analysis, from the data at hand, of the resistances which impede the progress of the bicyclist, and the work that the cyclist performs. In the subjoined discussion we have in the main followed closely the work of this writer, making the necessary conversion from the Metric to the English system of units.

The resistances that impede the progress of the bicyclist are as follows:

1. The resistance due to the rolling friction of the bicycle tires upon the surface of the ground.
2. The resistance (positive or negative) due to grade.
3. The resistance due to the friction of the balls in their bearings, and that due to the chain and sprocket wheels.
4. The resistance due to the vibration of the frame and other parts of the wheel.
5. The resistance offered by the air.
6. The resistance due to the application of the brake.

1. The resistance due to the rolling friction of the bicycle tires upon the surface of the ground.

Representing this resistance by R_1, it can be expressed by the following formula:

$$R_1 = \frac{M+B}{r}.c,$$

in which c is the coefficient of rolling friction, M the weight of the rider, B the weight of the bicycle, and r the radius of the wheels (assumed equal to each other).

The values of c adapted to English units (inches) are:

For poor roads, $c = 1.20$

For fair roads, $c = 0.40$

For good macadamized roads, $c = 0.20$

For excellent roads, such as asphalt or wood pavements, $c = 0.06$, to 0.08.

These values are taken at one-half those given by Morin, in his experiments, made with non-elastic tired wheels in which the resistance due to vibration was added to that due to rolling friction pure and simple. Experiment shows that the introduction of the pneumatic tire, practically annihilating vibration, has reduced the values of c to those given. (With cushion tired

* See *La Revue d' Artillerie*, March, 1896.

vehicles, it seems proper to observe, the value of c here given would have to be increased, probably by about $\frac{1}{4}$).

Assuming the mean weight of a man to be 143 pounds and the mean weight of the bicycle to be 33 pounds, and taking the radius of the wheels at 14″, this formula gives, for a race course ($c = 0.06$), $R_1 = 0.7546$ pounds.

2. The resistance due to grade.—This is evidently given by the formula:

$$R_2 = (M + B) \sin a = (M + B) \frac{h}{s},$$

in which a is the inclination of the grade from the horizontal, and h the rise for a given length of road, s.

3. The resistance due to the friction of the balls and that of the chain and sprocket wheels.—With the bearings and chain properly *cleaned*, lubricated and adjusted, this resistance is negligible. For the bearings it is said to be less than $\frac{1}{1000}$ of the total load.

4. The resistance due to vibration.—In a poorly made bicycle, without pneumatic tires, the work absorbed by the vibration may amount to as much as one-fourth of the whole. With rigid frames and pneumatic tires this source of resistance has almost disappeared, and can be neglected.

Taking from the machine the brake, mud guards, etc., as is now commonly done, is more for the purpose of relieving it from the vibration of these light and loose parts than to reduce the load by a few ounces. In the same way, the use of too light tubing may give rise to vibration, so that a medium weight wheel actually runs with lighter draft than one excessively light.

5. The resistance of the air.—Experiment shows that the resistance of the air is sensibly proportional to the square of the velocity, and is a function of the form, and area of plane surface, opposed to it. For a cyclist, dressed in a close-fitting costume, this resistance may be expressed in pounds by the formula:

$$R_3 = .002295\ V^2\ S,$$

in which S is the mean plane surface in square feet, and V the velocity in f. s.

Assuming the mean plane surface offered by the cyclist and his machine as 5.84 square feet, we have,

$$R_3 = .002295\ V^2.$$

This formula is adapted to the cyclist in racing costume; in ordinary garb, it becomes

$$R_3 = .00297\ V^2.$$

With loose, flowing garments R_3 becomes still greater.

6. The resistance due to the application of the brake.—Considering the direct acting "plunger" brake, this resistance will vary directly with p (pressure, in pounds per square inch, say, at which the brake is applied); F, the coefficient of friction between the tire and brake surfaces, and ρ the ratio of the lever-arms through which the brake resistance and the tractive force respectively act. In the case in consideration, these lever-arms are equal, being each the radius of the wheel. We therefore write, $R_4 = F.p$. F will depend upon the nature of the material of the brake, but will in any case be very large, equal to .75, 1.00, or even greater. Assuming F to be 1, and the multiplying power of the brake handle to be 3, we have

$$R_4 = 3\,p.$$

The brake resistance is not, of course, like the others discussed, since the brake is only *temporarily* employed to check speed, while the other resistances (with the exception in some few cases of that due to grade) are *incessant* in their nature. It is, however, an important matter to consider, since, as we have seen, upon the brake's efficiency depends largely the proper control of the machine.

Draft.—The general formula for the draft, then, becomes:

$$D = R_1 + R_2 + R_3:$$

(to this R_4 must be added, when the brake is applied.)

Taking the sum of the terms as above deduced, we have

$$D = c.\,\frac{M + B}{r} \pm (M + B)\,\frac{h}{s} + .002295\,V^2$$

With the preceding numbers, to wit:

Weight of man, M, 143 pounds;
Weight of wheel, B, 33 pounds;
Radius $r = 14''$;

this formula gives us for the draft (pull) on a horizontal ground, *upon a good macadamized road*, with a speed of V feet per second,

$$D \text{ (pounds)} = 2.5143 + .002295\,V^2 \text{ (} V \text{ in f. s.)}$$

This formula offers the solution of an interesting question:

At what speed does the resistance of the air become equal to that of the rolling friction?

We have, *for a race track*,

$$V^2 = \frac{.7546}{.002295}\,;\ \therefore\ V = 12\tfrac{1}{3} \text{ f. s. or about 8.1 per hour.}$$

For a good macadamized road,

$$V^2 = \frac{2.5143}{.002295}; \therefore V = 22 \text{ mi. hr.}$$

Hence, on a race course, (or any very smooth pavement), the resistance due to the air begins to preponderate at a speed of 8.1 miles per hour. On the road it should begin to preponderate between $12\frac{1}{2}$ and 22 miles per hour (depending upon the co-efficient of rolling friction, c.)

It will also appear from the foregoing discussion why a comparatively light head wind, such as a footman would hardly notice, is so perceptibly felt by the wheelman. To illustrate, take the case of a wheelman, going at a speed of, say, 10 miles per hour, air quiescent, who suddenly encounters a light head wind of, say, 5 miles per hour; the air resistances, before and after, are as $10^2 : (10 + 5)^2$, or as 100 : 225, an increase of 125% for a breeze that a footman would scarcely notice.

Does a wind at right angles to the cyclist's course impede his progress? The common opinion is that it does not, but this is erroneous. The varying intensity of a side wide continually disturbs the equilibrium of the moving bicycle, and the rider, to maintain his balance, is obliged, as it were, to continually "shift sail," and steer out of or into the wind. For winds of high velocity, the resistance due to this cause is very appreciable.

Work done in driving a bicycle, power required.—The work expended by a cyclist in foot pounds per second, or power, is equal to the product of the effort (draft) by the space covered per second or velocity.

That is,

$$P = D \times V.$$

Application to the record of Windle.—In the record of Windle, V was 59.8 f. s., and if we assume, as before, $M + B = 176$ pounds, $r = 14''$, and the co-efficient of rolling friction on an excellent track, with zero grade, $c = 0.06$, the formula above gives $P = 1077$ foot pounds per second, *or almost two horse power.* A man walking scarcely ever exerts more than 145 foot pounds per second; a bicyclist scarcely ever exerts more than 50 foot pounds per stroke of pedal, whilst Windle exceeded 290 foot pounds per single thrust. To exert more than 50 foot pounds per pedal stroke, the average cyclist has to force himself, and surpasses the maximum continuous effort of which his muscles are capable. Exhaustion, indeed, follows more frequently from the exercise of over-pressure than from over-rapidity of stroke; for though on the one hand, a man may succeed by well directed training in increasing to an almost indefinite extent the number

of muscular contractions of the *mean* intensity that he is able to endure, on the other hand there is, not only a certain muscular effort which he cannot possibly *surpass*, but cannot, even nearly approach with any degree of frequency.

The effort which a man can exert on a pedal, is then, limited; while on the other hand a man cannot give continuously more than *three thrusts on the pedals per second.* The gear of the machine must therefore be maintained compatible with this maximum of force and speed, and it would accordingly appear that no mechanism, however ingenious, could give a single rider on a bicycle propelled by his own exertions, a greater speed than that which he can attain with the present driving apparatus, properly geared. Indeed, it may be stated, that, *as a racing machine*, the bicycle as now constructed scarcely admits of improvement.

If, however, we place two men on a bicycle, (tandem), or three men on a "triplet," we may double or triple the driving power of the machine without correspondingly increasing the resistances.

It is due to this fact that a considerably higher speed can be attained on these machines than upon the single cycle. We shall have more to say on this point farther on.

Work to be exacted from the cyclist.—Captain Paloque gives an interesting discussion on this point, from which we summarize.

Experience proves that the amount of work that a man can perform, day in and day out, on a given machine is as follows:

The intensity of the applied force varies between ¼ and ⅙ of the maximum that he can exert on the machine.

The speed given the machine varies between ¼ and ⅙ of this maximum.

Finally, the duration of his work varies between ½ and ⅓ of a maximum day's labor (say 18 hours).

In the case in hand, the draft of the bicycle is, as we have seen, fixed (5 to 11 pounds) under ordinary conditions, so that we have nothing here to change.

The maximum speed may be taken at 32 miles per hour; we will therefore take an average of 7½ miles per hour.

The maximum duration being 18 hours, we will take for a suitable day's work, 7 hours.

It therefore appears that the work that can be demanded of a cyclist daily, for an indefinite period, without injury to his health corresponds on a "good" road to a speed of about 7½ miles per hour for 7 hours of road work, or a distance of 50 miles daily.

A cyclist thus trained will be able, on occasion, to compass in a forced march a distance of from 95 to 125 miles in one day.

The above estimate, is to say the least, conservative. On good macadamized roads, I should place the distance per day which an *individual cyclist* could accomplish, day in and out, at not less than 75 miles; Captain Paloque's figures may, however, be taken as a conservative estimate of the distance *that a considerable body* of cyclists could cover at a certain *average* speed in a given time.

Comparison of the work of wheeling and that of walking.—To walk at the rate of 3.5 miles per hour a man expends about 36 foot pounds of energy per step of 30", or 20 foot pounds per lineal foot. The bicyclist at the same rate of speed expends about 2.43 foot pounds.

A man who runs at the rate of 7.5 miles per hour expends about 22 foot pounds per lineal foot; the cyclist at the same speed expends but 2.15 foot pounds.

If we now compare the work of the pedestrian with that of the cyclist for a given distance, say 22.5 miles, we see that the footman at the rate of 3¾ miles per hour will take 6 hours to cover the distance, and will expend 1,737,000 foot pounds of energy. The cyclist, at the rate of 7.5 miles per hour, will require but 3 hours, and will expend only 260,000 foot pounds. At 15 miles per hour he would complete the journey in 1½ hours, expending 521,000 foot pounds.

The rate of work is as follows:

For the footman, at	3¾ miles per hour	: 80.58 foot lbs. per second.
For the cyclist, at	3¾ miles per hour	: 8.39 foot lbs. per second.
" " " "	7.5 " " "	: 24.16 " " " "
" " " "	15 " " "	: 96.56 " " " "

If we remember that the pedestrian is erect on his feet, and in walking has but one point of support, while his feet have a discontinuous movement and strike the ground in successive shocks; while the bicyclist is seated, has four points of support (the saddle, both hands, and the foot moving downward), and the movement of his body is continuous and without jar, we can easily account for the advantages which the latter has over the former in point of exertion required and celerity.

Accepting, then, 7½ miles per hour as the *normal* rate of march of a column of cyclists, let us see how nearly that rate can be maintained under varying conditions. Experience proves that the least fatiguing rate of pedal stroke for long, continuous riding is about 1½ per second; accepting this, we have 360 complete

crank-axle revolutions per mile, corresponding to a gear of 56", and a development of 14⅔ feet per each crank revolution. We will assume 6"⅜ as the length of the crank ("crank throw"), which experience proves to be the best for all around purposes. This corresponds to a mean crank leverage of

$$\frac{1}{2}\left[\frac{\pi \times (6.375)^2}{2 \times 6.375}\right] = 5'',$$

nearly.

We may also take a man power at from $\frac{1}{10}$ to $\frac{1}{12}$ of a horse power, as the work that a man is capable of performing for a day at a time, day in and day out, with a maximum exertion of from 4 to 6 times as great that he can put forth for considerable periods to overcome temporary impedances. That these figures are fair is abundantly shown by experiment.

We will therefore take an average of 50 foot pounds per second, with a maximum of from 200 to 250 per second for short intervals, as the work that can reasonably be expected of a military cyclist. This corresponds, at the rate of 7½ miles per hour, under the conditions assumed, to a mean pedal thrust of 15.59 pounds, with a maximum for shorter intervals of from 60 to 80 pounds. At 5 miles per hour, the mean thrust (for 50 foot pounds per second expended energy) becomes 23.38 pounds; with a maximum of from 90 to 120 pounds.

1. With zero grade and wind, what is the maximum coefficient of rolling friction c at which the assumed gait (7.5 miles per hour = 11.25 foot seconds) may be continually maintained? What is the maximum coefficient at which a slower gait (5 miles per hour) may be maintained *for short periods?*

We have,

$$c = \left[D - .00\overset{*}{2}97\,V^2\right]\frac{r}{M+B} = \left[15.59\ \frac{2 \times 5}{56} - .00\overset{*}{2}97\,(11\tfrac{1}{4})^2\right]\frac{14}{176}.$$

Therefore, $c = .192$, or nearly .2

This, as will be seen from the preceding discussion, corresponds, as it should, to a "good" road. At the reduced rate, *using the maximum effort*, the formula gives $c = 1.37$, showing that it is possible to travel several miles at this rate over roads worse than the poorest classified by Captain Paloque ("poor" road, $c = 1.2$).

2. Assuming a "good" road and zero head wind, what is the maximum grade that can be climbed at 7.5 miles per hour, for short distances?

We have:

$$(M+B)\frac{h}{s} = D - c\frac{M+B}{r} - .00297^{*}\, V^2;$$

or

$$176\frac{h}{s} = 80\frac{2 \times 5}{56} - .2 \times \frac{176}{14} - .00297\,(11\tfrac{1}{4})^2 \;\therefore\; \frac{h}{s} = \frac{1}{16},$$

or about 330 feet to the mile.

By reducing the speed to 5 miles per hour, the formula gives as the maximum grade the cyclist can climb at this gait

$$\frac{h}{s} = \frac{1}{10.6},$$

or 500 feet to the mile.

3. Assuming a "good" road and zero grade, what is the maximum head wind that can be encountered against which the bicyclist, at the assumed rate (7.5 miles per hour) can make headway for short distances?

The formula gives:

$$.00297\,(11.25 + V)^2 = D - c\,\frac{M+B}{r} \;\therefore\; V = 51.7 \text{ f. s.},$$

or 34.5 miles per hour.

Therefore, against a wind of 35 miles per hour, the cyclist could just make headway at a speed of 7.5 miles per hour.

At 5 miles per hour, $V = 72.08$ f. s., or 48 miles per hour.

4. On a "good," level road, what is the minimum distance in which the cyclist can stop his machine, using the brake and back pedaling, when he is moving at the above rates?

The maximum pedal thrust in back pedaling is, for comparatively *slow* speeds, evidently the rider's weight; taking it then, at 143 pounds, and the maximum pressure (grip) exerted on the brake handle at 30 pounds, we have:

$D = 143\,\frac{2 \times 5}{56} =$ the resistance due to back pedaling.

$R_1 = 2.51$, the resistance of rolling friction.

R_2, the resistance of the air, practically negligible in this case.

$R_4 = 3 \cdot p = 90$ pounds, the resistance due to the brake.

Therefore $R = 25.53 + 2.51 + 90 = 118$ pounds.

The mass moved is $\dfrac{w}{g} = \dfrac{176}{32.16}$

* We take the larger co-efficient (.00297 rather than .00295) in computing the wind resistance as the one that would more nearly conform to service conditions.—[See equation on page 184.]

Therefore the *retardation*, is $\rho = 118 \times \frac{32.16}{176} = 21.56$ f. s.

Hence, $s = \frac{V^2}{2\rho} = \frac{(11.25)^2}{43.12} = 2.935$, or say 3.0 *feet*.

That is, he would require one yard, or about half the length of his wheel.

At a speed of five miles per hour we have: $s = 1.3$ *feet*.

Practically, the brake would be applied more gradually; but the figures given show how effectually a bicycle can be controlled by a skillful rider using a powerful brake, in an emergency. Let us illustrate this point further by one or two more important examples.

5. What is the maximum grade that the bicyclist can descend at the rate of 7.5 miles per hour, by simply back pedaling, with the condition that he shall be able to bring his machine to a standstill in its own length (6 feet), without the use of the brake?

Here, we have:

$$R = 25.53 + 2.51 - 176\frac{h}{s} = 28 - 176\frac{h}{s} \text{ pounds.}$$

$$\frac{w}{g} = \frac{176}{32.16}; \therefore \rho = \left(28 - 176\frac{h}{s}\right)\frac{32.16}{176}$$

$$\text{Hence } s = 6 = \frac{(11.25)^2}{2\left[28 - 176\frac{h}{s}\right]\frac{32.16}{176}};$$

whence

$$\frac{h}{s} = -\frac{1}{9.86} \text{ or } -535 \text{ feet to the mile.}$$

That is, at the moderate rate of 7.5 miles per hour, the brakeless bicycle not only can not be brought to a stop within its own length on any down grade, but to do so requires an up grade of over $\frac{1}{10}$, or 535 feet to the mile.

To bring the bicycle, thus driven, to a halt on the *level ground*, the bicyclist using the maximum force (his weight) would require, as shown by the formula, a distance of nearly 13 feet. On a down grade of 300 feet to the mile, he would require a minimum distance of 20 feet. Practically these figures would be about doubled, for it would be rare indeed that a bicyclist could throw the whole weight of his body immediately on the pedals in back pedaling.

Under the same conditions, *with the brake*, the rider could stop his wheel, as follows:

a. In its own length, six feet: *on a down grade of ⅓ or a grade of 1800 feet to the mile.*

b. On the level: *as we have seen (Prob. "1"), in three feet.*

c. On a grade of 300 feet to the mile ($\frac{1}{17}$): *in 3.43 feet.*

Influence of the weather on bicycling.—The state of the weather affects the bicyclist in much the same manner that it does all kinds of wheeled locomotion. This effect is of two kinds:

1. Subjective: As regards the physical condition of the rider, and the effort that he can put forth and sustain. Manifestly the capability and endurance of a man for work are much reduced by excessive heat, humidity, driving rain, &c. These conditions are, however, entirely independent of the bicycle, and with them we have no concern in the present discussion.

2. Objective: As regards the resistances which the bicyclist has to overcome. Here it is plain that the effect of the weather is chiefly made evident to the bicyclist through changes in the coefficient of rolling friction.

The effect of dry weather is to produce dust and a general breaking up and disintegration of the surface of the road; while that of wet weather is to produce mud, ruts, &c., due to an undue softening of the road surface. The character of the road bed thus becomes a matter of prime consideration.

On paved and metaled roads the effect of the weather is least noticeable. On a well-constructed pavement or macadamized road comparatively little dust will form in the driest portion of the year; and on the other hand there will at no time be any very great increase in the rolling friction due to rain. A well drained macadamized road, will, after the hardest shower, or even after a long period of rain, become practically dry in a few hours of good weather. We may say in general that such a road will fulfill almost perfectly the conditions for bicycling, and it would seem to me that military wheeling is there practicable at almost any season of the year when troops can be moved or employed.

On the other hand unpaved roads, such as are usual in the country districts, will generally be greatly affected by the weather conditions. These roads differ from each other as much as do the soils of the localities in which they are laid, and the extent to which the weather will affect them must depend upon this condition. In a general way, we may say, that there are two classes of such roads—those in which sand is the chief constituent and those in which clay is the chief element.

The roads composed chiefly of sand become very friable in

seasons of dry weather, and if subjected to heavy teaming are badly cut up, so that the coefficient of rolling friction is very large. Very light loads only can be drawn on such roads, and bicycling is out of the question. On the other hand these roads become settled and packed by the rain, and if not subjected to heavy traffic make most excellent bicycle roads. The two conditions are well exemplified by the beach, where we gradually pass, in the course of a few feet, from the unridable portion of dry sand above mean high water to the excellent riding afforded by that portion which the tide has left temporarily uncovered.

There is a great deal of this kind of road in the United States, along the Atlantic and Gulf seaboards and that of the Great Lakes, and in many of our large river valleys. During the Civil War it was the kind chiefly met in the principal theatre of operations in Virginia. A line, drawn through Washington, Fredericksburg, and Richmond, limiting the tide water region of Virginia, will include about all of this country. Thus it will be seen that Grant's Overland Campaign, and nearly all of the four years of operations in the vicinity of Richmond, were conducted over these sandy roads. In time of peace there is usually to be found a footpath that is ridable, but such could not be hoped for in time of war after any considerable body of troops, and especially artillery and trains, had passed over the road.

On the other hand clay roads, when in fine condition, are not surpassed by any for bicycle purposes. Even in the driest weather, the dust formed on them is very light, and does not seriously impede the progress of the bicyclist. But rain makes them soft, sticky, and slippery, and continuous wet weather soon renders them altogether impracticable for military wheeling. If, in this condition, they are subjected to any traffic, they are badly cut up, and the ruts, drying and becoming stiff and hard, make bicycling for the time being far from pleasant. Even a light shower, such as in common parlance merely serves to "lay the dust," is very objectionable to the wheelman; for, first, the wheels pick up the mud which adheres to them, and become badly clogged by it—particularly in the kind of soil known as "adobe,"—and, secondly, the softened clayey road surface is such that the bicyclist must manage his machine very skillfully to avoid side-slipping and a bad fall. There is no denying that this is a weak point in the employment of the bicycle on these roads in campaign.

A good illustration of the two types of road described is to be found in the San Joaquin River Valley, California. On the east-

ern side of that river, the country is very sandy. In the dry season (say from May 1 to October 15th) there is almost absolutely no rain; the roads, in consequence, become very heavy, and loads have to be hauled through from three to six inches of sand. During the wet season, on the contrary (October 15th to April 30th), there is generally a copious fall of rain, and the roads soon become packed down into the smoothest and firmest pavement imaginable—making an almost ideal road for bicycling.

On the west side of the San Joaquin the country is clayey, with much "adobe." In consequence, in the wet season it is almost impassable and entirely unfit for cycling, while in the dry season the roads are most excellent for this purpose.

In some localities where sand and clay exist in proper proportions, especially where there is a plentiful supply of gravel, they unite in a kind of matrix for the harder constituents, forming roads most excellent during nearly the whole year. Such roads are to be found in many of the foothills of the Blue Ridge and other eastern mountain ranges, as well as oftentimes elsewhere.

Elimination of the chain.—Without doubt the chain constitutes the most troublesome feature of the safety type bicycle. Dust, sand and mud adhering to it cause it to run with a great deal of friction and to rapidly wear itself away. It is difficult to keep it properly lubricated, and this difficulty is increased by the fact that nearly all lubricants containing oil assist not only in retaining the dust, etc., that falls upon the chain, but also in the process of wear that takes place between it and the sprocket wheels. It is a singular fact that the leading manufacturers, who take such great pains to make the other wearing parts of their bicycles practically dust proof, should so neglect this important detail.

A more serious objection lies in the ease with which the machine may be rendered useless through a breaking of the chain, brought about by some obstacle being caught between it and the rear sprocket wheel. The end of a projecting piece of brushwood, a loose stone or stick thrown up by the wheel, or a portion of the clothing, being carried by the chain to the sprocket wheel, will usually result either in the breaking of the chain or the twisting of the frame of the machine, throwing the wheels out of alignment; and in either case the machine is for the time being rendered useless. That this accident is of common occurrence, a visit to a repair shop will soon prove.

Light chain cases have from time to time been devised, but have never been entirely satisfactory, as they interfere with the

cleaning and adjustment of the chain, increase the weight and vibration of the wheel, and yet are so frail that they are easily deformed and rendered a nuisance. Yet it would seem that something of the kind is almost indispensable, if the chain is to be continued as a part of the mechanism of the military bicycle.

Attempts have been made both in this country and Europe to do away with the chain entirely, for the reasons above cited.

The elimination of the chain constitutes one of the chief advantages claimed for the fron-tdriving safety, or "geared ordinary." Here, as will be remembered, the power is applied directly to the front wheel, and the gearing by which the requisite speed is attained lies concealed in the axle and is thus rendered practically dust proof. A French military bicycle has been built on this principle.

In the rear-driving safety the problem of chain elimination presents more difficulty. Various devices consisting of linkwork (crank and connecting rod) on the one hand or a train of spur wheels, or bevel wheels connected by a pitman, on the other hand, have been tried and have met with a fair degree of success; but the necessity for such innovations has not been generally felt by the average rider, with the result that the principal manufacturers still continue to equip their product with chains as the simplest and in general most satisfactory method of transmitting the power from the crank axle to the driving wheel. But for the military machine, as we have just seen, the protection of the chain, or its entire elimination, is an important matter.

Portability.—The principle has been laid down by several writers, and I believe it is a sound one, that the bicycle should be so constructed that wherever it cannot carry its rider, the rider shall be able to carry it. In other words, the military bicycle should be made portable.

The portability of the bicycle is brought about first, by making it as light as possible consistent with strength; this, we have seen, for a single rider gives a minimum weight of about 32 pounds; and, secondly, by so constructing the bicycle that it can be folded up into a convenient package and slung from the shoulders like an ordinary knapsack or other impedimenta. Several machines have already been devised whereby this is possible.

In this way the bicyclist is made to a great extent "independent of road and weather conditions." Not only will it be possible to so transport the bicycle when bad roads are temporarily encountered, but the bicyclist can go across country, or in fact

anywhere that it is possible for infantry to go; and his field of usefulness thus becomes greatly enlarged.

Résumé.—From the foregoing discussion we can formulate the following general statements in regard to the characteristics that the military wheel should possess:

1. To insure sufficient strength, the machine should be built of the finest material and should weigh at least 32 pounds.

2. The tires should be pneumatic "puncture proof" and extra heavy. Tires of large cross-section (2."5 in diameter) are judged best.

3. The military bicycle should be equipped with a powerful brake. The direct acting plunger brake is thought best. The brake should be made renewable and of such material that the wear should be upon it rather than upon the tire.

4. The chain must either be eliminated or shielded by a suitable case.

5. The bicycle should be made portable.

6. The bicycle should be "blued" or enameled so as to protect it from oxidation; a dull black or grey finish should be given to all its parts, to render them as inconspicuous as possible.

7. All minor details, such as quick and easy adjustment and replaceability of wearing parts; comfortable saddles; and fasteners for carrying the necessary luggage, arms, etc., must be carefully considered and worked out.

With a properly built bicycle, we have shown:

1. A column of bicyclists, on good roads, can maintain with ease a uniform gait of 7.5 miles per hour, for 7 hours, or cover a distance of 50 miles daily. Carrying the luggage on the wheel, this distance would be about equivalent to a march of 10 or 12 miles for infantry on the same road, carrying their luggage on the back.

2. On a good road it is possible for the cyclist, by calling on his reserve power, to ascend, for considerable distances, grades of $\frac{1}{16}$, or 330 feet to the mile; by reducing the speed to 5 miles per hour, he can climb grades of $\frac{1}{11}$, or 500 feet to the mile. It may be noted in this connection, that the maximum gradient permissible for the engineer to adopt, in laying out a road through a mountainous country, is $\frac{1}{20}$; and this only where it cannot be avoided.*

3. With the aid of a suitable brake it is possible for the cyclist

* "No gradients upon any complete road projected for wheel traffic, in any situation, should be permitted to exceed in steepness 1 on 20."—Treatise on Mountain Roads and Bridges, by Lieutenant-General H. St. Clair Wilkins, R. E. p. 73.

to control his bicycle and bring it to a standstill within the of its own length, on any grade or in any circumstances lik be met with in road service. The necessity, however, of b able to see his path for some distance in advance, to allow pr steering, would, except on fine roads require a cyclist to m tain a greater average distance. An average distance of 15 between riders, it is thought, would be ample under all circ stances.

4. It is possible to travel for comparatively short distanc roads where the co-efficient of rolling friction is as high as This would probably be represented by about two or three in of loose sand, deep mud, &c.

5. Where riding is not practicable on the road, the w man, dismounted, can maintain about the same gait as ordi infantry on the same road, and by carrying the baggage on wheel, probably will in most cases get along with as little e tion as the average infantryman with his luggage on his bac

6. By making the bicycle portable the wheelman can as a resort, carry his machine where trundling it is not practica either on account of excessively heavy or muddy roads, o going across country.

Lieutenant William C. Davis, 5th Artiller

[*To be concluded.*]

HISTORY OF THE SEA-COAST FORTIFICATIONS OF THE UNITED STATES.

Read before the Maine Historical Society, April 26, 1889.
[Reprinted from the *Maine Historical Society Quarterly*, January, 1896.]

I. PORTLAND, MAINE.

THE ANCIENT DEFENSES OF PORTLAND.

The first defensive work erected in Portland Harbor was the fortified house of Captain Christopher Levett, an English gentleman of Somersetshire. He was one of those adventurous mariners who in the sixteenth and seventeenth centuries carried the standard of England wherever ships could sail. He received his patent of six thousand acres from the Council of Plymouth on the fifth of May, 1623. He was himself a member of the council, which, in 1620, when the charter was conferred by James I., consisted of the Duke of Lenox, the Marquis of Rockingham, the Marquis of Hamilton, the Earl of Arundel, the Earl of Warwick, Sir Ferdinand Gorges and a number of other gentlemen.

After sailing along the New England coast in the summer of 1623, on a voyage of search for a good location, he fixed his habitation on one of the islands of Casco Bay, one of four he speaks of, "which make one good harbor." His relation of the voyage to the council runs:

And thus, after many dangers much labor and great charge, I have obtained a place of habitation in New England where I have built a house and fortified it in a reasonable good fashion, strong enough against such enemies as are these savage people.

That Levett was a humorist as well as an explorer is evident from his succeeding observation to the council:

"I will not do," he writes, "therein as some have done to my knowledge, speak more than is true: I will not tell you that you may smell the cornfields before you see the land; neither must men think that corn doth grow naturally (or on trees); nor will the deer come when they are called and stand still and look on a man until he shoot him, not knowing a man from a beast; nor the fish leap into the kettle nor on the dry land; neither are they so plentiful that you may dip them up in baskets," etc.

The identity of his island is an open question among the historians of Maine. Mr. James Phinney Baxter in the valuable

"Trelawny Papers" makes it House Island on which Fort Scammel now stands. Mr. William Goold in "Portland in the Past" makes it Hog Island, now euphemistically known as Great Diamond Island, and Mr. William M. Sargent in "An Historical Sketch, Guidebook and Prospectus of Cushing's Island," fixes it upon that beautiful place. The latter is probably the more exact surmise. That Levett had no confidence in any permanently peaceful relations with the Indians is evident from his prompt action in putting the new house in defensive condition. He writes of them :

> They are very bloody-minded and full of treachery among themselves * * * therefore I would wish no man to trust them, whatever they may say or do, but always to keep a strict hand over them and yet to use them kindly and deal uprightly with them.

At the time of his settlement, plantations had already been established at Portsmouth and Dover, New Hampshire, and further eastward on Monhegan Island. It is not likely that he would build his fortified house on an interior island, and so, in the event of hostilities which he manifestly looked for, cut himself off either from giving aid by sea to, or receiving it from either flank of the line of settlements. As all three were holdings under the Gorges and Mason patent, it is reasonable to assume that they were under instructions to help one another in the event of war. From the standpoint of strategy, the principles of which endure from age to age almost unchanging, either House Island or Great Diamond Island would have placed him at a disadvantage with the enemy on Cushing's Island ; but holding the latter he would have had a certain strategic advantage which is obvious. This island has been known at different times as Portland Island, Andrews' Island and Bangs' Island. As Andrews' Island it was the refuge of the settlers in King Philip's war in 1676, who fled from Munjoy's garrison on the "Neck," and constructed some sort of a defense on the inner slope of the picturesque rock of White Head. It is probable that not only was this island chosen as an asylum for facility of relief by sea from other settlements to the westward, but because some part, if not the whole, of Levett's fortified house still stood where his trained hand had built it and gave them safe refuge ; and relief accordingly came during the summer from Black Point and Boston.

The first fortification constructed in Portland was Fort Loyal. It was a bastioned fort, built of stockades and stood on a rocky bluff at an elevation of about thirty feet above high-water mark

near the foot of India Street and the ground now occupied by the roundhouse of the Grand Trunk Railroad Company. It became the center and rallying point of the settlement. Its construction was begun by order of the General Court of Massachusetts, by English soldiers, under command of Captain Hawthorn in September, 1676.* The site had a gradual slope towards the water front and contained about one-half acre. It consisted of a number of log buildings used as barracks, guard-house and shops, all surrounded by palisades. Wooden towers on the interior served as stations for observation and defense. The whole was loopholed and had emplacements for eight pieces of ordnance, which composed its armament. In 1690 a small work of semi-circular front stood about one mile west of the fort on an elevation in rear of a swamp which extended to the water-front.

Ingersoll's blockhouse stood a half-mile southwest of the fort and Lawrence's blockhouse, built of stone and timber, stood about three-quarters of a mile north on Munjoy's Hill. The first notable use of Fort Loyal was as a prison for some twenty Indians, who were treacherously seized at Saco and sent there for safe keeping. They were subsequently released by Governor Andross and afterwards attained greater or less celebrity as relentless foes of the colonists. Among them was Hopegood, a chief of the Norridgewocks. It served its first legitimate use in 1689 when Major Church of Massachusetts saved the town and fort from destruction by his timely arrival by sea from Boston with several companies of troops, consisting of whites and negroes and friendly Indians from Cape Cod. He found the French and Indians four hundred strong about to attack the town, and to conceal his presence landed his troops at the fort after dark. The action was begun early on Saturday morning, the twenty-first of September, 1689. Church was embarrassed by finding that the musket balls he had brought in his supplies of ammunition were generally too large for his guns. With the aid of the people of the town, he had them hammered into slugs, and, after a hard fight drove off the invaders. This engagement was fought near Deering Park about two miles from Fort Loyal.

A glance at the state of Europe at this time will show what relation its men and events bore to the obscure little outpost in the Province of Maine. The English revolution of 1688 had deprived James II. of his crown and put his son-in-law, William Prince of Orange, and Stadtholder of the Netherlands, and his

* William Hawthorne or Hathorne, of Wilton, Wiltshire, England, was the first American progenitor of Nathaniel Hawthorne.

eldest daughter, Mary, upon the English throne. It was the age of Louis XIV. and the brilliant soldiers, scholars and politicians who, in that era, made France glorious. Vendome, Catinat and Turenne were leading the troops of the great monarch in the campaigns which made their names dear to Frenchmen, but hateful to the people of the Netherlands and the Palatinate. Bossuet was preaching those wonderful sermons which marked him as one of the foremost pulpit orators of tne Christian church. Louvois was at the head of affairs, the greatest war minister of his time.

James II. had left his mimic court at Saint Germain and was getting what force together he could in Ireland for the recovery of his throne.

Schomberg was collecting an army of thirty thousand men in the north of Ireland, who were destined to beat the French and Irish at the battle of the Boyne on the first day of July.

Macaulay tells us that the cause of James was the cause of France and under this pretense, Count Frontenac, the able governor of New France, quick to second his sovereign in his ambition for the glory of his reign, planned a campaign in America to force the English boundaries to retreat as far southward as possible. Frontenac had returned as governor and lieutenant-general of New France in October, 1689, charged with instructions to initiate a campaign against New York and Boston, operating with his land forces from Montreal and with his fleet from Quebec. Looking at the map of America of 1655, the territory of England embraced at that time only the present states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, Maryland and Virginia.

A colony of Swedes held Delaware ; the Dutch held the valley of the Hudson and New Jersey as far south as Cape May ; Spain held Florida, and France the immense territory now comprised within the states of New York, Pennsylvania, Ohio, Kentucky, West Virginia, Tennessee, the Carolinas, Georgia, Alabama, Indiana. Illinois and Michigan. In 1690 the English boundaries included Pennsylvania, Delaware, New York and the Carolinas. LaSalle had made his immortal journey through the Mississippi Valley to the Gulf of Mexico, and had taken possession of the country in the name of his Most Christian Majesty.

The people of Massachusetts and Maine had recognized the title of William and Mary and with more zeal than discretion had driven Sir Edmond Andross from power and were active in overthrowing all the good effects of his measures for their defense

against the French and Indians. In his report to the committee for trade and plantation, which was received in London in April, 1690, he writes:

That the new council in Massachusetts under Governor Bradstreet gave orders for the withdrawal of the forces from Pemaquid and other garrisons and places in the eastern parts; that the Indians were encouraged and enabled to renew and pursue the war and by the assistance of the French who have been seen among them * * * increased their number; that in a short time several hundred of their Majesties' subjects were killed or carried away captive; the fort at Pemaquid taken, the whole county of Cornwall, the greater part of the Province of Maine, and that part of New Hampshire destroyed and deserted.

The military state of the provinces of Maine and New Hampshire was about as bad as it could have been. Indifference on the part of the Massachusetts Governor and Council to the military necessities of the frontier, involving criminal neglect in providing rations, clothing, camp equipage, ordnance, arms and ammunition for the garrisons; inefficiency in the commissioned officers, insubordination and ignorance in the soldiery all made the success of Frontenac a foregone conclusion. It is hardly to be doubted that his plans were materially changed on his arrival, for he found it necessary to drive the Iroquois from Montreal and secure the safety of his own people against them.

In the spring of 1690 three expeditions were sent out to strike at the English settlements. The right column, consisting of one hundred and ten French troops under command af Manet, with St. Helene and Iberville, two sons of Charles LeMoyne, in charge of the Indian contingent, marched from Montreal through the snow and attacked Schenectady on the third of February, killing sixty people and ravaging the country. The center column, consisting of twenty-four French soldiers and twenty-five Indians, led by Hopegood, all under command of Francois Hertel, left Three Rivers on the twenty-eighth of January and arrived at Salmon Falls, New Hampshire, on the twenty-seventh ot March. The town was attacked at daybreak, partially destroyed and many of the inhabitants murdered and carried into captivity. Hertel withdrew on learning that help to Salmon Falls was coming from Portsmouth, and made his way to the Kennebec to join his force to that of the Count de Portneuf, who commanded the left column, then on its way to attack Fort Loyal. This command consisted of fifty French soldiers and fifty Abnaki Indians from the Mission of St. Francis in the Province of Quebec. They left Quebec in January, arriving in Casco Bay on the eleventh or twelfth of May. On the twelfth of

May two Englishmen were caught on the Bay, one of whom was killed and the other carried off. On the same day, Captain Sylvanus Davis reported to the governor and council of Massachusetts the defection of Captain Simon Willard and some of his men, who in the face of the enemy and in the most cowardly manner fled from Casco to Boston on a wretched pretense. In the meantime the Count de Portneuf had concentrated his forces on the islands in the harbor and on the night of the fifteenth of May landed on the north end of the peninsula in Indian Cove at the foot of Munjoy's Hill. Their lines were deployed in the timber north of Queen, now Congress Street, facing to the southeast. Their forces amounted to about four hundred men in all, Portneuf in command, with his fifty Frenchmen and fifty Abnakis, Hertel with his twenty-four Frenchmen and twenty-five Abnakis and Baron de Castine with the Abnakis headed by Madockawando and Hopegood. The fighting strength of the garrison consisted of about seventy men. At noon on the sixteenth, thirty men under command of Lieutenant Clark made a sortie in the direction of the Lawrence garrison-house on Munjoy's Hill and were attacked and all killed but five, who made their way, all of them wounded, back to the fort. On the night of the sixteenth all the people who were in the four outer garrison-houses retreated to the fort, which was soon completely invested. The enemy set fire to the buildings in the town, and ran a trench towards the walls for the purpose of setting fire to the stockades. When the trench was completed they filled a cart with combustibles, ran it close to the walls and set fire to it. This danger led to a parley which resulted in the surrender of the garrison on the twentieth of May, on condition of safe conduct to the nearest English town. The terms were made with Portneuf and were ignored as soon as made. The Indians slaughtered all without regard to age or sex. About five of the garrison, including Captain Davis and two daughters of Lieutenant Clark were spared and taken to Quebec and ultimately exchanged. The story of the siege, taken from the French archives, relates that "the fort was fired, the guns spiked, the stores burned and all the inmates made prisoners. The Indians retained a majority of them." One of the singular features of this engagement is that the casualties up to the day of the surrender seem to have been unusually small. On the side of the French and Indians, the French report says that "One Frenchman had his arm broken by a cannon ball and an Indian received a wound in the thigh." On the part of the English there were apparently no

casualties except the killing of Lieutenant Clark and his party, and the wounding of the five who got back to the fort on the sixteenth. It is estimated that nearly two hundred people were massacred or carried into captivity. Those of the other settlements fled for safety to the more secure towns of New Hampshire.

The garrison which at this time held Purpooduc or Spring Point, retreated with those of Spurwink and Scarborough to Saco. In the autumn of 1690, while on an expedition against the Ameriscoggins, Major Church landed five companies of English soldiers and friendly Indians at Spring Point, the present site of Fort Preble. He was attacked at daylight on Sunday, September 21, and after a sharp fight repulsed them with a loss to his force of seven killed and twenty-four wounded. It is supposed that this fight took place on the swampy ground lying between Fort Preble and Cushing's Point.

The armament of Fort Loyal was left in the ruins of the work when the French and Indians quit the place. In August, 1692, Sir William Phipps with a force of four hundred and fifty soldiers under command of Major Church, sailed from Boston for Pemaquid, where he began the construction of Fort William Henry. On his way up he stopped at Falmouth, buried the whitened bones of the victims of the massacre and took the guns with him to form part of the armament of the new fort at Pemaquid.

After the people of Maine had become reasonably assured of safety on the negotiation of the treaty of Mare Point, in January, 1699, they returned to Casco Bay and began a new settlement near the mouth of the Presumpscot River.

At a point about three miles northeast of the old location of Fort Loyal and four miles nearly due north of Spring Point a fort was constructed in 1700 under direction of Colonel Romer, a military engineer of the provincial government. It was known as New Casco Fort.

This work was built on four sides of a square, each side being fifty feet in length. Small bastions were placed in the northeast and southwest corners, and high sentry-boxes overlooking the surrounding country on the northwest and southeast corners. The whole was surrounded by a stockade. About one hundred feet southeast of the fort was the well on which the garrison depended for water, the avenue to which was also secured by a line of stockades on each side. The area enclosed by the work exclusive of that of the bastions and sentry-boxes was twenty-

five hundred square feet. The faces of the bastions were thirty feet long.

The little fort justified the propriety of its construction when Queen Anne's war was begun in 1703. It was then the utmost frontier of the English on the east. The French and Indians, five hundred strong, under command of the Sieur de Beaubussin laid siege to it for several days in August of that year. The settlers had found safety within its walls. The post was commanded by Major March, who had an effective force of thirty-six men, which he divided into three reliefs of twelve each. Their defense was so bravely conducted that the French commander was forced to begin regular approaches, which were interrupted by the timely arrived from Boston of Captain Southback in an English man-of-war in the service of the Massachusetts authorities.

He attacked the enemy, destroyed many of their canoes, and raised the siege. It was only in June of this year that Governor Dudley of Massachusetts, whose administration was begun in 1702, had held at this fort an imposing council with the Indians, which ended in protestations of the most peaceful intentions on both sides. After this visit and the attack of the French and Indians, he directed a new fortification to be constructed, which was finished in 1705, under the superintendence of Colonel Redknap, an engineer officer in the service of Massachusetts, who was afterwards sent with March's command to conduct the siege operations in the unsuccessful expedition against Port Royal despatched by Dudley in June, 1707. The stockades of the new fort entirely circumscribed those of the old. The new fort was an oblong qradrilateral having regular bastions at all its corners. Exclusive of the bastions it was two hundred and fifty feet long and one hundred and ninety wide. In each side a sally-port was provided, the one on the east having a small stockaded redan in its front. The length of the bastioned front on the north and south sides was two hundred and fifty-eight feet and on the east and west three hundred forty-six feet respectively. Its interior area, not counting that of the bastions was about forty-seven thousand five hundred square feet, or a little more than one acre.

Within the walls, barracks, storehouses, officers' quarters and shops were erected and in the southwest corner a large tank was put up for the storage of water in time of siege. From the south sally-port, a sheltered way to the shore of the bay was built of stockades, the water ends of which flared outwardly and

extended into tide water to give a protected mooring for the boats of the garrison. No details of the armament are known. New Casco Fort continued to be the defense of Falmouth until 1716, when its garrison was withdrawn, its armament and stores removed and the work demolished by its commander, Major Moody, under orders from the colonial government. Most of the people moved their habitations to the old site of the town on the "Neck," where Portland now stands. The officers and soldiers who composed the garrison moved to the new town with the people, took up land and were among those who were called the new proprietors, as distinguished from the heirs of the former occupants, who were called the old proprietors. Queen Anne's war continued to rage until 1713, when it ceased under the treaty made at Portsmouth, New Hampshire, July 11, of that year. In 1731 the town applied to the General Court of Massachusetts for the construction of a fort for the public defense and a work was accordingly begun on the old site of Fort Loyal, but apparently not completed.

The provincial government was not unmindful, however, of the defense of the town, for on the eighteenth of August, 1738, Colonel Pepperell, with officers of the regular troops and militia, arrived from Boston and made an inspection of its military condition. This work was repaired and an additional breastwork built during Governor Shirley's administration in 1742, and in the war of the Spanish Succession and the French war, which resulted in the fall of Quebec and the Treaty of Paris, in 1762, was partially relied on for the defense of the town against the French. The armament of the new breastworks consisted of ten twelve pounders. After the capture of Louisburg by Sir William Pepperell in 1745, the French government dispatched the Duc D'Anville to America with a fleet of eleven ships of the line, twenty frigates, five ships and brigs, thirty-four fire ships, tenders and transports and three thousand one hundred and fifty men to recapture the fortress and restore the prestige of French power. The expedition was abandoned and the remnant of the fleet returned to France. The people of Falmouth, however, apprehensive of a visit from it, made preparations for defense by placing two old eighteen or forty-two pounders in a battery on Spring Point—a measure in which the means were hardly adequate to the ends expected. During this period the people wasted labor, money and materials by expending their efforts in building and strengthening the private garrisons or blockhouses,

instead of concentrating all on the development of the powers of the fort; and we find that in 1744 eighty-five soldiers were posted in the town and billeted in the garrison houses, which were designed for security in case of Indian attacks. When the war of the Revolution was begun the town was practically defenseless, and Mowatt with a fleet of four small English armed vessels shelled and destroyed Portland with absolute impunity. The only guns in the town were four old pieces and for these not a round of ammunition was on hand.

On the second of May, 1776, a local committee was appointed to look after the defense of the town. One fort was constructed on Munjoy's Hill and another on the hill on Free Street, where the Anderson mansion stands. The fort on Munjoy's Hill was named Fort Allen in honor of the captor of Ticonderoga, and that on Free Street was known as the Upper Battery. A battery and magazine also stood on or near the ground selected for the monument to be erected to the memory of the soldiers and sailors of Maine who fell in the war of the Rebellion, and another on the old site of Fort Loyal. Breastworks were constructed on Spring Point and garrisoned by a company of artillery; and a small battery was thrown up on Portland Head, in which a detachment was placed with orders to report the appearance of strange vessels by firing signal guns. This was the condition of the defense of Portland during the war of the Revolution.

After the Revolution the fortifications of the country were permitted to fall into decay, but when hostilities with France became imminent about 1794, Congress appropriated large sums of money for putting the coast defenses in good condition. Pursuant to this determination a fort was constructed on Munjoy's Hill which subsequently became known as Fort Sumner, in honor of the memory of Governor Sumner of Massachusetts. It is thus described by the Duc de la Rochefoucauld who about this time made a tour of the United States with Talleyrand:

They are at present constructing on the site of an old earthen breastwork a fortification which they expect to command the town and to render it at least secure from the invasions of an enemy. This new fortification stands at the extreme point of the peninsula on which Portland is established and consists of a battery of fifteen or twenty heavy cannon of large caliber commanding that wide entrance of the bay which was above mentioned. This battery is to have by means of a covered way a communication with a small fort a distance of four or five hundred toises (about eight hundred or a thousand yards) which it has been thought necessary to erect on the highest part of the isthmus. The fort is sufficient to hold two hundred men."

In his history of Portland Willis thus describes it:

The barracks were erected on the summit of Munjoy's Hill surrounded by an earthen embankment beneath which was a deep ditch. It was connected by a covered way with a battery erected on the southerly brow of the hill near where Adams street now [1865] passes. Guns were mounted at both places, but the barracks for the accommodation of the men and the parade ground were within the enclosure on the hill. It was garrisoned until after the war of 1812, when the command was withdrawn and the work suffered to go to decay.

In anticipation of war with England in 1808, Congress again made generous provision for coast defense, and as a part of the general plan Forts Preble and Scammel were begun in that year and completed before 1812.

The state of Massachusetts on the twelfth of March, 1808, passed an act ceding to the United States the jurisdiction of a part of House Island and the extreme end of Spring Point, opposite thereto, near the entrance of Portland Harbor, reserving to itself concurrent jurisdiction on and over said lands, so far as that all civil and criminal processes may be duly executed on the lands so ceded. Subsequently in section 8, chapter 2, of the revised statutes of Maine, the state passed a general act confirming the authority of the United States over any lands transferred to the government for public uses under the constitution and laws of the United States. This act has been construed by the courts of Maine as applying as well to military reservations as to lighthouses and other public buildings.

The first Fort Preble was built of brick and granite. Its front, on the channel, was semi-circular in plan, and on its flanks and rear it had the lines of a star fort.

This part of the work is still standing. The length of the superior slope from the interior to the exterior crest was ten feet, six inches, and on the land side, near the sally-port, four feet and two inches. The command or height of the interior crest above the site was eighteen feet and four inches. Inside the enclosure were two double buildings for officers' quarters, a shot furnace, magazine, barracks, and a well. Its armament consisted of seven thirty-two pounders, five eight-inch howitzers and one twelve pounder, all mounted in barbette.

In reply to a request for information addressed to an officer ot the Adjutant-General's Department, on duty in the War Office, as to the personage after whom Fort Preble was named, the following was received:

WAR DEPARTMENT,

ADJUTANT-GENERAL'S OFFICE,
DIVISION MILITARY INFORMATION.

MERMOANDUM:

In the matter of Fort Preble, Maine. Fort Preble was constructed some

time during the summer of 1808. The question of fortifying the Atlantic seacoast towns was a matter of much concern from 1794 for the following ten years. A battery and blockhouse were erected for the defense of the town in 1795 and 1796, but these soon fell into decay. A small work which had been authorized by the act of March, 1794, was completed in 1806, and received the name of Fort Sumner, but the site of this work was injudiciously selected, and the engineers reported that new works were necessary. Under date of January 6, 1809, President Jefferson, in a message to Congress on the subject of seacoast defense reports: "Portland Harbor, Fort Preble, a new enclosed work of stone and brick masonry with a brick barrack, quarters and magazine, is completed. This work is erected on Spring Point, and commands the entrance of the harbor through the main channel."

This is the record we have of the existence of Fort Preble. The records of the War Department in 1820 are very meager. A fire in the War Department in 1800 consumed most of the records prior to that date, and on the approach of the British in 1814, the records which had accumulated up to that date were either destroyed or distributed in such a manner that few of them have been recovered. It may have been that the designation of this work originated in the War Department, but of this there is no certainty. The names of most of the early works were conferred upon them by the constructing engineers, and not always with the approval of the department.

It has always been considered by this office that Fort Preble was named in honor of the memory of Edward Preble, Commodore in the United States Navy. He was perhaps the most prominent naval officer of his day, and his operations along the Barbary coast, which resulted in the peace of the third of June, 1805, by which the tribute which European nations had paid for centuries to the Barbaric pirates was abolished, and his efforts were renowned throughout the world. He returned to this country in 1805, where he received an enthusiastic welcome as well as a vote of thanks from Congress (the first to receive them after the adoption of the Constitution), and a gold medal.

In 1806 President Jefferson offered him the portifolio of naval affairs, which he declined on account of his feeble health. He returned to Portland, his native town, where he died in August, 1807. It was at this time that the new work in Portland Harbor was under construction and about being completed, and it is therefore reasonable to suppose that the compliment of bestowing his name upon the work would have naturally suggested itself to those in authority. In fact, the preponderance of opinion is shown from a consultation of numerous authorities to incline to that view.

On the other hand, beyond the fact that the father of Commodore Preble (Jedediah) was a Brigadier-General in the Revolutionary army, his services during the war of the Revolution were not of so distinguished a character as to have entitled him to the honor in question, twenty-five years after his death, in contradistinction to his son, who was unquestionably the most eminent citizen of Portland at the time of his death, which was contemporaneous with the naming of the work.

The first Fort Scammel is thus described by Mr. William Goold in "Portland in the Past."

On the highest point of this purchase (the military reservation of Fort Scammel) Dearborn erected an octagonal blockhouse of timber with a pointed roof of eight sides. On the low upright center timber of the roof was placed a carved wooden eagle with extended wings; on each of the eight sides of

Old Ft. Casco
The Brother's
CASCO BAY
Cow I.
Crow I.
Mackey's Pt.
Martin's Pt.
Mackey's Id.
Graves Hill
Steven's Plain
Westbrook.
E. Deering.
Cemetery
U.S. Marine Hospital
Halfway Rock
Presumpscot R.
Back Cove
Woodfords
Pumpkin Nob
Hussey's Sound
Lit. Hog
Hog I. Ledge
FT. GORGES
Hog I. Roads
Peak's Id.
House I.
FT. SCAMMEL
FT. PREBLE
White Head
Ferry Village
Fore R.
Reform School
Cape Elizabeth
Knightville
Ram I.
Ship Cove
Portland Head
Pond Cove
Zeb's Cove
Peeble's Pt.
Trundy's Pt.
ATLANTIC OCEAN
EASTERN R.R.
MAINE CENTRAL R.R.
PORTLAND
AND
VICINITY
SCALE OF MILES
1 ½ 0 1 2 3

the blockhouse was an embrasure or porthole and a gun. The upper story contained the battery, and projected over the lower story two or three feet. All the buildings, including the blockhouse and barracks, were clapboarded and painted white. The works were enclosed in an earthen rampart, and presented a picturesque appearance.

Fort Scammel was so named in honor of Colonel Alexander Scammel of the army of the Revolution, who was aide-de-camp to General Washington and Adjutant-General of the army. He was mortally wounded by Hessians while engaged in a reconnaissance near Yorktown, Virginia, September, 1781.

Both posts were named by direction of Major-General Henry Dearborn, United States army, who was Secretary of War from 1801 to 1809, and whose son, Alexander Scammel Dearborn was the agent of the War Department in the construction of Forts Preble and Scammel.

During the war of 1812, temporary batteries were constructed on Fish Point and Jordan's Point. The latter was named Fort Burrows in honor of the gallant commander of the United States brig *Enterprise*, who fell in the action with the English brig *Boxer*, on the fifth of September, 1813, off Portland Harbor. In the old cemetery on Munjoy's Hill, his body lies side by side with that of his heroic antagonist, Captain Samuel Blythe of the Royal Navy, who fell at his post of duty on the *Boxer* early in the action.

The defenses of Portland, like those of other cities on the coast, have been affected by the development of modern artillery.

In 1857 it was found necessary to make radical changes in Forts Preble and Scammel and to construct Fort Gorges. These works were all to be large masonry forts with two tiers of casemate batteries and one barbette each, mounting in all, for the defense of the harbor, two hundred and ninety pieces of artillery. Before their completion the system of heavy smooth-bore guns was superseded by the modern heavy built-up breech and muzzle-loading rifles, and the costly and elaborate fortifications of granite were found to be useless against such artillery.

The corps of engineers spent no more money on masonry works, but in 1871 they strengthened Forts Preble and Scammel by the construction of heavy earthen parapets, traverses and magazines, and emplacements for modern artillery. Fort Preble has platforms for seventeen fifteen-inch Rodman guns or twelve-inch rifles, and for three eight-inch rifles. There are now (1889) two fifteen-inch S. B. guns and two eight-inch rifles mounted in

the works. Fort Scammel has six fifteen inch and four ten-inch S. B. guns mounted and emplacements for several others.

It is understood that the new project of the engineer corps for the defense of Portland Harbor embraces the construction of modern works with the necessary electrical and steam plant on Portland Head and Cow Island.

The compiler of these notes is especially indebted to Mr. James Phinney Baxter of Portland, Maine, for access to and free use of valuable maps of the coast made by early explorers and plans of the early fortifications of the New England coast, copies of which Mr. Baxter secured at private expense from the Public Records office, the Rolls Office and the Library of the British Museum in London; also for giving him access to the valuable collection of the Maine Historical Society. He is also indebted for courtesies to Mr. William Goold, author of *Portland in the Past,* and to Messrs. S. W. and Charles Pickard, editors of the *Portland Transcript.* In preparing these notes the following authorities have been consulted:

Palfrey's History of New England.
Willis' History of Portland.
Williamson's History of Maine.
Mather's Magnalia.
Sullivan's History of Maine.
Goold's Portland in the Past.
Hull's Capture of Fort Loyal.
Smith and Deane's Journals.
An Historical Sketch, etc., of Cushings Island, by Wm. M. Sargent, A. M.
The Trelawney Papers, by Mr. James Phinney Baxter.

THE RESISTANCE OF AIR TO THE MOTION OF PROJECTILES.

Translated from the Italian in the Rivista di Artigleria e Genio, February, 1896.

SECTION ONE.

It was shown at the close of our last article that the resistances given by the asymptote of our hyperbola for high velocities are somewhat lower than those given either by Zabouski's formulas or the Krupp tables; "but (it was stated) these differences are of very little consequence; none in fact, till the relation existing between the original experimental data and Zabouski's formulas or Krupp's tables is well known." This was written December 4, 1895, after several unsuccessful attempts, both in Italy and elsewhere, to obtain the data referred to.

On the 13th of January 1896, we received through the courtesy of a colleague (Major F. Mariani) pamphlet XXX of the "*Schiess-Versuche der Gusstaklfabrik Fried. Krupp auf ihrem Schiessplatz bei Meppen,*" which bore the special title "*Versuche zur Ermittelung des Luftwiderstands bei grossen Geschoss-Geschwindigkeiten.*" And the Krupp people themselves kindly sent us on the 23rd of January, in addition to the before-mentioned pamphlet, a lithographed sheet with a complete and exact description of experiments conducted on the 9th with the highest velocities.

Pamphlet XXX contains an account of the identical experiments referred to by Mayevski in his work "*Ueber die Lösung der*

Date.	No. of shots.	Caliber.	Weight. p.	Cross section.	Distance x, between p'nts where v_1 and v_2 were measured.	v_1	v_2	Weight Δ of a cubic meter of air.	log δ	log C	a
		cm.	kg.	cm²	m	m	m	kg.			
5 7 81	2	10.5	4.00	86.6	470	909.9	607.4	1,192	9.99493	9.55963	0.365
		"	4.00	"	370	839.9	607.4	"	"	9.55963	0.365
5 7 81	1	"	4.02	"	470	818.6	580.8	"	"	9.56280	0.307
		"	4.02	"	370	779.7	580.8	"	"	9.56280	0.326
5 7 81	4	"	4.01	"	970	900.1	438.1	1.179	9.99017	9.56172	0.308
		"	4.01	"	870	853.2	438.1	1.179	"	9.56172	0.312
9 11 82	4	8.7	4.00	59.4	421.5	837.4	664.1	1.268	0.02177	9.72336	0.319
9 11 82	5	"	"	"	924	835.2	487.6	1.302	0.03326	"	0.315
9 11 82	6	"	"	"	1424	838.7	367.9	1.275	0.02416	"	0.323

Problemen,"* relating to projectiles of 10.5 and 8.7 centimeters, fired with velocities of 933 and 861 meters. We take from this pamphlet (pages 2 and 3) all the experimental data relative to firings with these velocities.

The quantaties δ, C and a are not found in the tables of the pamphlet, but have been calculated by us in the following manner:

$$\text{Evidently, } \delta = \frac{\Delta}{1.206}.$$

Remembering that the expression for the ballistic coefficient is

$$C = \frac{p}{1000\, a^2},$$

(p and a being the weight and diameter of the projectile in *kg* *m*), and that the cross-section in cm² is

$$Q = \pi \left(\frac{100\, a}{2}\right)^2,$$

we have

$$\frac{p}{Q} = \frac{4p}{10000\, \pi\, a^2} = \frac{4\, C}{10\, \pi},$$

whence

$$C = \frac{10\, \pi}{4} \frac{p}{Q}.$$

The quantity α is introduced in order to determine whether the retardation given by hyperbola $[1]_1$, or by its asymptote,

$$r = \frac{\delta}{C}(0.327\, v - 86) = \frac{\delta}{C}\, 0.327\, (v - 263)$$

is higher or lower than that given by experiment. We have therefore supposed that the retardation may be expressed by

$$r = \frac{\delta}{C}\, \alpha\, (v - 263),$$

and then determined the value of α for each firing.

Neglecting the effect of gravity which is very small on account of the great flatness of the trajectory, we may write

$$\frac{v\, dv}{dx} = -r = -\frac{\delta\, \alpha}{C}(v - 263),$$

$$\frac{\delta\, \alpha}{C}\, x = -\int_{v_1}^{v_2} \frac{v\, dv}{v - 263} = v_1 - v_2 + 263 \text{ Nap. log} \left(\frac{v_1 - 263}{v_2 - 263}\right),$$

whence

$$\alpha = \frac{C}{\delta\, x}\left[v_1 - v_2 + 2.302585 \left(263 \log \frac{v_1 - 263}{v_2 - 263}\right)\right].$$

* See page 366, Journal for May-June.

From this equation we computed the last column in the table. Taking the arithmetical mean of the values of a, we have

$$a = 0.327,$$

which is precisely the coefficient which appears in the equation of the asymptote.

Without attaching too much importance to this coincidence, but rather recognizing it to be accidental, we may nevertheless conclude that these firings, executed as they were with the highest velocities, agree remarkably well with hyperbola [1].

The results of the Meppen firings on January 9, 1896, described in the before-mentioned lithographed sheet, are recapitulated in the following table :

No. of shots.	Caliber.	Weight, p.	Distance between points where v_1 and v_2 were measured.	v_1	v_2	Weight of a cu. cm. of air.	log δ	log C	a
	m	kg	m	m	m	kg			
5	0.065	4.9	435	759	672	1,324	0.04054	0.06437	0.334
	"	"	500	672	582.5	"	"	"	0.325
5	"	"	435	807	717	"	"	"	0.334
	"	"	500	717	620	"	"	"	0.339
5	"	"	435	877.5	783	"	"	"	0.336
	"	"	500	783	681.5	"	"	"	0.335
5	"	"	1435	808	534.5	1.330	0.04250	"	0.335
6	"	"	1435	871	583.5	1.330	0.04250	"	0.334

The mean of the values of a is here 0.334, while the coefficient of the asymptote is, as we have seen, 0.327. The coincidence is not exact, but the difference is quite small, and would tend to be even smaller if account were taken of the wind, which was blowing at the time with a velocity of from 3 to 5.3 meters in a direction almost exactly opposite to the motion of the projectiles.* On the other hand, every projectile has its own coefficient of form, as appears from the Krupp tables themselves. But even without attending to these considerations, the difference between 0.327 and 0.334 is so small that far from modifying, it does but

* If we wish to take account of the velocity of the wind, let ω be the component of this velocity opposed to the motion of the projectile whose velocity is v. The resistance encountered by the projectile will be equal to that which it would suffer in still air if its velocity were $v + \omega$. Therefore the retardation will be,

$$r = a\,(v + \omega - 263)\,\frac{\delta}{C},$$

and in the expression for a we have only to substitute $263 - \omega$ for 263.
Hence,

$$a = \frac{C}{\delta x}\left[v_1 - v_2 + 2.302585(263 - \omega)\log\frac{v_1 + \omega - 263}{v_2 + \omega - 263}\right]$$

confirm, the conclusions deduced from the experiments of 1881.

If there is any correction to be made in the values given by hyperbola [1], it is in those relating to velocities below 200 m., which are a little large. This correction is easily obtained by means of a small additional term which vanishes when the velocity exceeds a certain limit. Of this additional term we will speak in a subsequent article.

SECTION TWO.

Calculation of the ballistic functions, $D(u)$, $T(u)$, $J(u)$ and $A(u)$.

The four ballistic functions, D, T, J, A, are defined by the equations,

$$D(u) = -\int \frac{u\,du}{F(u)},\ T(u) = -\int \frac{du}{F(u)},\ J(u) = -\int \frac{2g\,du}{u\,F(u)}$$

$$A(u) = -\int \frac{J(u)\,u\,du}{F(u)} = \int J(u)\,d\,.\,D(u),$$

where $F(u)$ is the resistance function, which, adopting hyperbola [1] of the preceding article (Section 2), is expressed by

$$(1)\quad F(v) = \frac{Cr}{\delta i} = 0.1925\,v - 48.11 + \sqrt{(0.1725\,v - 47.89)^2 + 21.12}.$$

Placing $v = u$, and introducing this expression under the integral sign, the integration in the case of D, T, and J is effected by means of algebraic and elementary logarithmic functions. The fourth function is calculated numerically by means of the values of $D(u)$ and $J(u)$.

Calculation of $D(u)$. Let us place

$$(2)\quad \begin{cases} p = 0.1925,\ a = 0.1725,\ b = 47.89,\ c = 48.11 \\ R = \sqrt{a^2u^2 - 2abu + c^2}, \end{cases}$$

from which we have, noting that $(47.89)^2 + 21.12 = (48.11)^2 = c^2$,

$$F(u) = pu - c + R.$$

Therefore

$$(3)\quad D(u) = -\int \frac{u\,du}{pu - c + R} = -\int \frac{u\,du\,(pu - c - R)}{(pu - c^2) - R^2} =$$

$$-\int \frac{du\,(pu - c - R)}{(p^2 - a^2)\,u - (2pc - 2ab)}.$$

Make

$$(4)\quad k = \frac{2pc - 2ab}{p^2 - a^2} = 274.0137,$$

and note that k is the abscissa of the point where the second branch of the hyperbola cuts the axis of velocities (see fig. (1) of preceding article). In fact the abscissas of the points where the hyperbola cuts the axis of velocities are given by

$$pu - c \pm R = o,$$

or by

$$(p^2 - a^2)u^2 - (2pc - 2ab)u = o.$$

One of the points is the origin ($u = o$), and the abscissa of the other is given by (4).

We see further that having made $u = k$ in $pu - c - R = o$, this equation becomes an identity; whence we have

(5) $$pk - c = \sqrt{a^2k^2 - 2abk + c^2},$$

and we may write,

$$D(u) = -\frac{1}{p^2 - a^2}\int \frac{du}{u - k}(pu - c - R).$$

As regards the rational part, we have at once

$$\int \frac{du}{u-k}(pu - c) = \int \frac{du}{u-k}[p(u-k) + (pk - c)]$$
$$= pu + (pk - c) \text{ Nap. log } (u - k),$$

omitting the constant of integration, which will appear in the final formulas.

As to the irrational part, let us make

(6) $$\left\{ \begin{array}{l} u - k = z, \; b - ak = B, \\ pk - c = \sqrt{a^2k^2 - 2abk + c^2} = C, \end{array} \right.$$

and we have

$$R = \sqrt{a^2z^2 + 2(a^2k - ab) + a^2k^2 - 2abk + c^2} = \sqrt{a^2z^2 - 2aBz + C^2}$$

$$\frac{R}{z} = \sqrt{a^2 - \frac{2aB}{z} + \frac{C^2}{z^2}}$$

$$\int \frac{R\,du}{u-k} = \int \frac{R\,dz}{z}.$$

Integrating by parts,

$$\int \left(\frac{R}{z}\right) dz = \left(\frac{R}{z}\right) z - \int z\, d\left(\frac{R}{z}\right)$$

$$= R + \int \frac{z\left(aB - \frac{C^2}{z}\right) d\,\frac{1}{z}}{\sqrt{a^2 - \frac{2aB}{z} + \frac{C^2}{z^2}}}$$

$$= R - aB\int \frac{dz}{\sqrt{a^2z^2 - 2aBz + C^2}} - C^2\int \frac{d\,\frac{1}{z}}{\sqrt{a^2 - \frac{2aB}{z} + \frac{C^2}{z^2}}}$$

$$= R - B \text{ Nap. log}\,(R + az - B) - C \text{ Nap. log}\left(\frac{R}{z} + \frac{C}{z} - \frac{aB}{C}\right)$$

$$= R - B \text{ Nap. log}\,(R + az - B) - C \text{ Nap. log}\left(R + C - \frac{aBz}{C}\right)$$

$$+ C \text{ Nap. log}\, z.$$

Substituting the values of z, B, and C, as given by (6), and observing that

$$C - \frac{aBz}{C} = \frac{C^2 + aBk - aBu}{C}$$

$$= \frac{a^2k^2 - 2abk + c^2 + ak(b - ak) - a(b - ak)u}{pk - c}$$

$$= \frac{(c^2 - abk) - au(b - ak)}{pk - c},$$

we obtain

$$\int \frac{R\,du}{u - k} = R - (b - ak) \text{ Nap. log}\,(R + au - b)$$

$$-(pk - c) \text{ Nap. log}\left[R + \frac{(c^2 - abk) - au(b - ak)}{pk - c}\right]$$

$$+ (pk - c) \text{ Nap. log}\,(u - k),$$

and finally

$$(7) \quad D(u) = -\frac{1}{p^2 - a^2}\left\{pu - R + (b - ak) \text{ Nap. log}\,[R + au - b]\right.$$

$$\left. + (pk - c) \text{ Nap. log}\left[R + \frac{(c^2 - abk) - au(b - ak)}{pk - c}\right]\right\}.$$

Calculation of $T(u)$. We have

$$T(u) = -\int \frac{du}{pu - c + R} = -\frac{1}{p^2 - a^2}\int \frac{du}{u(u - k)}(pu - c - R);$$

and because

$$\frac{1}{u(u - k)} = \frac{1}{k}\left(\frac{1}{u - k} - \frac{1}{u}\right),$$

this becomes,

$$T(u) = -\frac{1}{(p^2 - a^2)k}\int\left(\frac{du}{u - k} - \frac{du}{u}\right)(pu - c - R)$$

$$= \frac{D(u)}{k} + \frac{1}{(p^2 - a^2)k}\int \frac{du}{u}(pu - c - R).$$

For the rational part we have at once,

$$\int \frac{du}{u}(pu - c) = pu - c \text{ Nap. log}\, u.$$

For the other term, integrating by parts,

$$\int\left(\frac{R}{u}\right)du=\left(\frac{R}{u}\right)u-\int ud\left(\frac{R}{u}\right)$$

$$=R+\int\frac{u\left(ab-\frac{c^2}{u}\right)d\,\frac{1}{u}}{\sqrt{a^2-\frac{2ab}{u}+\frac{c^2}{u^2}}}$$

$$=R-ab\int\frac{du}{\sqrt{a^2u^2-2abu+c^2}}-c^2\int\frac{d\,\frac{1}{u}}{\sqrt{a^2-\frac{2ab}{u}+\frac{c^2}{u^2}}}$$

$$=R-b\text{ Nap. log }(R+au-b)+c\text{ Nap. log }\left(\frac{R}{u}-\frac{c}{u}+\frac{ab}{c}\right)$$

$$=R-b\text{ Nap. log }(R+au-b)+c\text{ Nap. log }\left(R-c+\frac{abu}{c}\right)$$

$$-c\text{ Nap. log }u.$$

Therefore,

$$T(u)=\frac{D(u)}{k}+\frac{1}{(p^2-a^2)k}\Big[pu-R+b\text{ Nap. log }(R+au-b)$$

$$-c\text{ Nap. log }\left(R-c+\frac{abu}{c}\right)\Big];$$

and from (7)

$$(8)\quad T(u)=\frac{1}{(p^2-a^2)k}\Big\{ak\text{ Nap. log }[R+au-b]$$

$$-c\text{ Nap. log }\left[R-c+\frac{abu}{c}\right]$$

$$-(pk-c)\text{ Nap. log}\left[R+\frac{(c^2-abk)-au(b-ak)}{pk-c}\right]\Big\}.$$

Calculation of $J(u)$. We have

$$J(u)=-\int\frac{2g\,du}{u(pu-c+R)}=-\frac{2g}{p^2-a^2}\int\frac{du}{u^2(u-k)}(pu-c-R);$$

and because

$$\frac{1}{u^2(u-k)}=\frac{1}{k^2}\left(\frac{1}{u-k}-\frac{1}{u}-\frac{k}{u^2}\right)$$

this becomes,

$$J(u)=-\frac{2g}{(p^2-a^2)k}\int\left[\frac{du}{u-k}-\frac{du}{u}-k\frac{du}{u^2}\right](pu-c-k)$$

$$=\frac{2g}{k}T(u)+\frac{2g}{(p^2-a^2)k}\int\frac{du}{u^2}(pu-c-R).$$

For the rational part we have at once

$$\int \frac{du}{u^2}(pu - c) = p \text{ Nap. log } u + \frac{c}{u};$$

and for the other term, integrating by parts,

$$-\int \frac{du}{u^2}\; R = \frac{1}{u} R - \int \frac{1}{u} dR = \frac{R}{u} - \int \frac{(a^2 u - a b)\, d u}{u R}$$

$$= \frac{R}{u} - a^2 \int \frac{du}{R} - ab \int \frac{d \frac{1}{u}}{\frac{R}{u}}$$

$$= \frac{R}{u} - a \text{ Nap. log } (R + a u - b) + \frac{ab}{c} \text{ Nap. log } \left(\frac{R}{u} - \frac{c}{u} + \frac{ab}{c} \right)$$

$$= \frac{R}{u} - a \text{ Nap. log } (R + a u - b) + \frac{ab}{c} \text{ Nap. log } \left(R - c + \frac{a b u}{c} \right)$$

$$- \frac{ab}{c} \text{ Nap. log } u.$$

Hence,

$$J(u) = \frac{2g}{k} T(u) + \frac{2g}{(p^2 - a^2)k} \left\{ \left(p - \frac{ab}{c} \right) \text{ Nap. log } u + \frac{R + c}{u} \right.$$

$$\left. - a \text{ Nap. log } (R + au - b) + \frac{ab}{c} \text{ Nap log. } \left(R - c + \frac{a b u}{c} \right) \right\};$$

and from (8)

$$(9) \qquad J(u) = \frac{2g}{(p^2 - a^2)k} \left\{ \left(p - \frac{ab}{c} \right) \text{Nap. log } u + \frac{R + c}{u} \right.$$

$$+ \frac{a b k - c^2}{c k} \text{ Nap. log } \left(R - c + \frac{a b u}{c} \right)$$

$$\left. - \frac{p k - c}{k} \text{ Nap. log} \left[R + \frac{c^2 - a b k - a u (b - a k)}{p k - c} \right] \right\} + \text{constant.}$$

Having a table of the numerical values of $F(u)$, (see Section 2 of the preceding article, remembering that $\frac{Cr}{\delta i} = F(u)$,) it will be useful to express R as a function of $F(u)$; thus,

$$(10) \qquad R = F(u) + c - p u$$

whence we have, writing F for $F(u)$,

$$R + a u - b = F + (c - b) - (p - a)u,$$

$$R - c + \frac{a b u}{c} = F - \frac{(p c - a b)u}{c},$$

$$R + \frac{(c^2 - a k) + (a^2 - a b k)u}{p k - c}$$

$$= F - \frac{k(p c - a b) - [(p^2 - a^2)k - (p c - a b)]u}{p k - c}$$

$$=F+\frac{(p^2-a^2)k(k-u)}{2(pk-c)}$$

Making these substitutions in (7), (8), (9), we obtain,

(11)
$$D(u)=\frac{1}{p^2-a^2}\Big\{F-2pu$$
$$-(b-ak)\text{ Nap. log }[F+(c-b)-(p-a)u]$$
$$-(pk-c)\text{ Nap. log }\left[F+\frac{(p^2-a^2)k(k-u)}{2(pk-c)}\right]\Big\}+\text{constant.}$$

(12)
$$T(u)=-\frac{1}{(p^2-a^2)k}\Big\{c\text{ Nap. log }\left[F-\left(\frac{pc-ab}{c}\right)u\right]$$
$$-ak\text{ Nap. log }[F+(c-b)-(p-a)u]$$
$$+(pk-c)\text{ Nap. log }\left[F+\frac{(p^2-a^2)k(k-u)}{2(pk-c)}\right]\Big\}+\text{constant.}$$

(13)
$$J(u)=\frac{2g}{(p^2-a^2)k}\Big\{\frac{F+2c}{u}$$
$$+\frac{pc-ab}{c}\text{ Nap. log }u-\frac{c^2-abk}{ck}\text{ Nap. log }\left[F-\frac{pc-ab}{c}u\right]$$
$$-(pk-c)\text{ Nap. log }\left[F+\frac{(p^2-a^2)k(k-u)}{2(pk-c)}\right]\Big\}+\text{constant.}$$

Substituting for p, a, b, c, k, their numerical values as given by (2) and (4), we obtain finally, after converting the Napierian into common logarithms,

(14)
$$\begin{aligned}D(u)=&+[2.1366771]\,(F-0.385\,u)\\&-[2.2931277]\log(F+0.22-0.02\,u)\\&-[3.1651898]\log(F+59.094-0.21566u)+C_1\end{aligned}$$

(15)
$$\begin{aligned}T(u)=&-[1.7433560]\log(F-0.020789\,u)\\&+[1.7356819]\log(F+0.22-0.02\,u)\\&-[0.7274173]\log(F+59.094-0.21566\,u+C_2\end{aligned}$$

(16)
$$\begin{aligned}J(u)=&+[0.9914476]\left(\frac{F+86.22}{u}\right)+[9.6714930]\log u\\&-[8.9407065]\log(F-0.020789\,u)\\&-[9.5821878]\log(F+59.094-0.21566\,u)+C_3\end{aligned}$$

The numbers in brackets are the logarithms of the coefficients whose places they occupy.

Calculation of $A(u)$.—Let us place $D(u)=z$, $u=f(z)$, and represent by $\overline{J}(z)$ and $\overline{A}(z)$ what $J(u)$ and $A(u)$ respectively becomes when $f(z)$ is substituted for u.

Since

$$A(u)=-\int J(u)\,\frac{u\,du}{F(u)}=\int J(u)\,dD(u)$$

we shall have

$$(17) \qquad \overline{A}(z) = \int \overline{J}(z)\, dz.$$

Now let us suppose to be calculated, by formula (14), a table of values ot $D(u)$, or of z, corresponding to the argument u; this table may be converted into another giving values of u corresponding to the argument z.

To the values of u in this second table will correspond certain values of $J(u)$ or of $\overline{J}(z)$, which may be calculated by (16).

Suppose that the interval between the z's of the second table is represented by Δ; the column of $\overline{A}$'s may then be calculated by Simpson's formula, thus;

$$(18) \qquad \overline{A}(z+2\Delta) = \overline{A}(z) + \frac{\Delta}{3}\left[\overline{J}(z) + 4\overline{J}(z+\Delta) + \overline{J}(z+2\Delta)\right].$$

If we desire to begin the ballistic tables at $u = 1000$, we may place $D(1000) = o$, $J(1000)$ or $\overline{J}(o) = o$, and $A(1000)$ or $\overline{A}(o) = o$; but this is not necessary; in fact it is better that the first value of J, and also of A and T, should not be zero, so that if one wish to extend the table we need not encounter negative values.

SECTION THREE.

Values of $D(u)$, $T(u)$, $J(u)$, for High Velocities.

For high velocities the hyperbola is not distinguishable from its asymptote, and we may place,

$$F(u) = 0.365\, u - 96,$$

or

$$F(u) = a(u - h),$$

where,

$$a = 0.365, \text{ and } h = \frac{96}{0.365} = 263.$$

This gives

$$(19) \qquad D(u) = -\int \frac{u\, du}{a(u-h)} = -\frac{1}{a}[u + h \text{ Nap. log}(u-h)] + C'_1.$$

$$(20) \qquad T(u) = -\int \frac{du}{a(u-h)} = -\frac{1}{a} \text{ Nap. log}(u-h) + C'_2.$$

$$(21) \qquad J(u) = -\int \frac{2g\,du}{au(u-h)} = -\frac{2g}{ah}[\text{Nap. log}(u-h) - \text{Nap. log}\, u] + C'_3.$$

Substituting numerical values,

$$(22) \qquad D(u) = -2.7397\, u - [3.2198785] \log(u - 263) + C'_1$$

$$(23) \qquad T(u) = -[0.799928] \log(u - 263) + C'_2$$

$$(24) \qquad J(u) = +[9.6724447] \log\left(\frac{u}{u - 263}\right) + C'_3$$

Finally, in order to determine the value of u where we may begin to use formulas (22), (23), (24), in place of (14), (15), (16), we have arranged in the following table the values of the functions given by the two groups of formulas, from $u = 1000$ m to $u = 300$ m. The constants are determined so as to make $D(1000) = 1000$, $T(1000) = 1.00$, $J(1000) = 0.100$, which is effected by placing,

$$C_1 = 20350, \qquad C_2 = 14.18, \qquad C_3 = -3.8997.$$
$$C'_1 = 8497, \qquad C'_2 = 19.09, \qquad C'_3 = 0.0377.$$

u	$D(u)$		$T(u)$		$J(u)$	
	14	22	15	23	16	24
1000	1000	1000	1.00	1.00	0.1000	0.1000
900	1379	1379	1.40	1.40	0.1083	0.1083
800	1776	1776	1.87	1.87	0.1190	0.1191
700	2198	2199	2.43	2.43	0.1337	0.1339
600	2658	2660	3.13	3.14	0.1554	0.1555
500	3184	3187	4.09	4.11	0.1900	0.1902
400	3836	3856	5.59	5.61	0.2560	0.2565
300	5010	5073	9.00	9.20	0.4538	0.4652

F. Siacci.
Colonel of Artillery, In the Reserve.

Naples, January 26, 1896.

[*Translated by* First Lieutenant F. S. Harlow, First Artillery.

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

a. Guns and Carriages.

The Progress of Artillery.

Since the introduction of the quick-firing element into apparatus associated with the loading, training, and elevation of heavy guns, which may be said to date from the spring of 1887, when the original 4.7-inch quick-firer was sent down from Elswick to be experimented upon at Portsmouth, no very striking or revolutionary change has been effected in the constitution of war material in this country. We mean such a change as that which was inaugurated when the muzzle-loading principle was abandoned in favor of breech-loading, when the old clumsy wrought-iron coiled system of gun construction was set aside to make way for the light, elegant tubes or hoops of steel which are clasped together in the formation of a modern weapon, or when the first thirty-eight-ton gun of the *Thunderer* was loaded and worked by mechanical power in 1875. Nevertheless, immense and important modifications have been quietly going on both ashore and afloat; and we now propose to consider briefly some of the more interesting features of this progress. It is with some satisfaction that we contemplate the history of artillery advance—as regards material—for the past nine years. Constantly accustomed to hear of the advent of some wonderful invention which was to revolutionize warfare—aërial torpedoes, gun-cotton rockets, dynamite guns, and other abnormal weapons—many have been in danger of overlooking the legitimate improvement of already existing types, by development of power and range, with a better system of construction, a greater length of bore, and the employment of a more powerful propellent. Since 1887, however, legitimate development has been steadily carried on. The monstrous, badly-designed, and badly-balanced heavy armament found upon the *Benbow* and *Sans Pareil* has been condemned in principle, and lighter, although infinitely stronger and more effective, weapons have taken its place. But it is in the secondary batteries afloat that the most marked improvement is observable. Here, without any "revolution," but by mere progress of ideas, the 6-inch ordinary breechloader of twenty-six calibers, which had been brought from Elswick to Woolwich so early as 1876, but had scarcely been altered at all up to 1887, has bloomed out into the 6-inch wired quick-firer of forty calibers, capable of penetrating sixteen inches of wrought iron, or nearly three times its own caliber. Ashore the same march of events is everywhere perceptible. In 1888 the condition of our fortress guns was absolutely deplorable. It was recorded in these columns that "not a single modern breechloader was mounted in any of our shore batteries from Lands End to John O'Groat's House;" and this was a fact. Yet at this moment a series of powerful detached positions, armed with 6-inch, 9.2-inch, and 10-inch breechloaders, and with 9-inch rifled howitzers, has been constructed around our coasts, and the coaling stations abroad are all completed in the same way. In the meantime the twelve-pounder breech-loading gun for field batteries has been improved into a fifteen-pounder, whilst a light

gun has been specially constructed for the horse artillery, a desideratum of very long standing. A field howitzer of exceptional powers has also been introduced into the Service. All these features are the result of that calm progress which, as we observed before, may be regarded with special equanimity.

Perhaps the most important instance of this development is the 9.2-inch wire gun, two of which will form the main armament of the *Powerful* and *Terrible*, now completing in Portsmouth Dockyard. This gun is to be 33 feet long, or no less than forty-three calibers, throwing a projectile of 380-pound weight, having a muzzle energy 14,520 foot-tons, or 6,000 tons more than the original 9.2-inch weapon, whilst its penetration through wrought iron is 28 inches, more than three times its caliber. But even these exceptional characteristics are to be thrown into the shade by those of the land service 9.2-inch wire gun, which is to be 38 feet long, or forty-nine and a half calibers. Its powers of range and velocity of projectile will, of course, be correspondingly increased, with the increase of five feet to the length of the bore. Another instance which may be cited is the 12-inch forty-six-ton wire gun of the *Majestic* type. This, whilst twenty-three tous lighter in weight than the 13.5-inch guns of the *Royal Sovereign* type, is actually 12.5 inches longer in the bore; so that although its projectile is only of 850 pounds instead of 1,350 pounds, with a cordite charge the muzzle energy is nearly 34,000 foot-tons, or only about 1,000 foot-tons less than that of the heavier gun, whilst the power of penetration is considerably greater. But with the improvements which have been effected in the loading arrangements for these forty-six-ton guns upon the *Majestic* the speed of working has been accelerated very materially. Three rounds can be fired from each gun in four minutes, whilst the guns of the *Royal Sovereign* require a period of one minute and three-quarters for each round; hence the striking effect of a succession of rounds from the *Majestic's* heavy guns would be incomparably greater than that of the guns from the other ship. Now the main principle of improvement which is involved in the case of these two guns is that which results from the employment of steel wire or tape in their construction, admitting of the employment of cordite as a propellent. The 12-inch gun is practically taped over at least two-thirds of its length, over one hundred miles of steel tape having been employed in this service, whilst the 9.2-inch gun has a large space over the powder chamber and a short distance beyond the trunnions reinforced in the same manner. It is a singular instance of the eccentricity with which inventions are treated that this system of reinforcing the circumferential strength of guns with steel wire should have been fully understood for many years, having been long ago invented by Mr. Longridge, but that its application, in any extended sense, should only have been adopted within the past five or six years. The fact is that the minds of scientists were so fully occupied with the desire for producing some startling invention that they lost sight of the natural development of improvements which had already been brought to hand. Mountings both for main armament and secondary batteries have gone ahead *pari passu* with the guns. So greatly has this process been realized within the past three years that loading of the heavy turret guns can be accomplished now in any position, whilst the ammunition is being rapidly fed up mechanically through the center of the mounting and the guns themselves are being trained upon any object. This is a most essential point to gain. In the earlier vessels the turret or turntable had to be trained until

the breeches of the guns were opposite the rammers, and then the guns had to be elevated until they were in the loading position. All this took a considerable time. One of the most singular features of adaptation in the present day is the application of electric motors to the various purposes of training and elevating heavy and secondary guns, and to the working of ammunition hoists. This power is being extensively employed in France, whilst hydraulic power is rapidly being abandoned. The balance of the new 6-inch quick-firers, and the ease with which they are manipulated, is most remarkable. Although the shield and movable portion of the mounting weighs together with the gun many tons it can be trained by one man with the greatest ease. The breech opening or closing mechanism with a single movement—this being actuated by a long lever with a small handle upon it as in the case of the twelve-pounder quick-firers—is being applied to all the 6-inch quick-firers now being mounted. It simplifies the action very much. As regards the land service ordnance, scarcely so much has to be recorded, but the advance is in the right direction. It was always a mistake to arm the field and horse artillery with the same weapon. The twelve-pounder was, with its ammunition, too light for the field artillery and too heavy for the horse batteries. The employment of a field howitzer to accompany field batteries is a most salutary change. Whilst the French military authorities most injudiciously added to their ordinary field batteries two mitrailleuses, which could only be a source of incumbrance to the gunners, and were a foreign weapon to them altogether, Germany and Russia very wisely adopted regular howitzer batteries, throwing a powerful and heavy shell of twelve centimètres. France has now at last done the same thing with a howitzer of similar caliber, and after a long series of experimental trials we have armed several of our field batteries with a 5½-inch howitzer, throwing a shell between 70 pounds and 80 pounds in weight. The importance of such a weapon can scarcely be over-estimated. With low charges and high elevation it would come into action under circumstances where ordinary field guns would from their flat trajectory be of no service, and would destroy an enemy's buildings and earthworks most effectually owing to its heavy projectile and bursting charge. Thus, both sea-service and land-service weapons have improved in value and importance quietly but surely.

—*Army and Navy Gazette*, July 25, 1896.

b. Armor.

Attack of Face-Hardened Plates by Capped Projectiles.

The various studies we have heretofore published in the *Génie Civil* upon Harveyized plates have brought out the great importance of the progress which the application of the process of cementation has enabled us to attain in the preparation of armor platés.

The invention of the mixed metal, or the application of steel in large masses to the preparation of armor plates, about ten years ago, more or less, enabled us to get even thin armor plates of much greater resistance than the welded iron ones used up to that time. In fact, if the velocity of perforation of ordinary steel is compared with that of iron, even then a difference of 18 to 20 per cent is found, which amounts to saying that a steel plate would scarcely be penetrated by a shock whose energy (proportional to the square of the velocity) was more than 40 per cent greater than one which would have sufficed to have ensured the perforation of an iron plate of equal thickness. More recently, the invention of special steels charged with chrome

and nickel, such as our French works can now turn out, gave a means of increasing still more the resistance to penetration and of obtaining plates in which the *velocity of perforation* exceeded by 12 per cent that of ordinary steel, and consequently by 32 per cent that of iron.

The face-hardened steel plates do better still, since they have a velocity of perforation exceeding by 20 per cent that of ordinary steel, and it is even known that by applying cementation to special steels, our works have been able to reach and exceed 30 per cent, as was the case in the comparative tests at Yavres. By comparing anew with iron, bringing in the energy of the shock, it is evident that these plates will be capable of stopping, as previously pointed out, a large steel projectile having a *vis viva* nearly thrice that which would have ensured the perforation of an iron plate of equal thickness, or nearly twice that of ordinary steel.

Such are the figures which indicate clearly the decisive influence of cementation, which thus seems to give to the plate, at least temporarily, a superiority over the projectile attacking it.

It must not be forgotten, however, that the struggle is still going on with continual fluctuations, and if, for a moment, we saw the triumph of the plate, it was to be forseen that the projectile would make strenuous efforts to regain its compromised superiority.

It must be admitted, in fact, that the result observed in the attack of hardened metal depends principally upon the special resistance of the outer skin, as it is the latter which, most frequently, causes the rupture of the attacking shell. The energy expended in the blow is thus principally absorbed by the shell, and the plate has only to withstand a materially weakened effort.

With projectiles of suitable hardness, a very considerable velocity must be reached to break through the face-hardened layer without rupturing the shell and at the same time ensure the perforation of the plate, hence the need for this excess of velocity may be regarded as due especially to the action of the face-hardened crust. It has been found, in fact, as Major Vallier has noted in an interesting paper published in the *Revue d'Artillerie*, that the number of fragments into which the shell is broken upon striking the face-hardened surface varies greatly with the velocity.

When this is relatively small, the projectile rebounds intact or broken into fragments: with a greater velocity, reduction to small pieces results; if still greater, the projectile again gives large pieces, the ogival head remains intact, but, on the other hand, the plate develops considerable heat, finally, with still greater velocity, we succeed in *passing through* the wall.

From this Major Vallier has been led to think that the perforation of face-hardened plates is subject to a special law, in which the velocity of the shot is decided by considering the case hardened layer alone without reference to what relates to the thickness of the plate, and he proposes to adopt for expressing this relation the following form, in which the velocity of the projectile referred to the unit of section, must give a relation greater than a constant number, and he adopts provisionally the expression:

$$p \frac{V}{a^2} > 1.5$$

in which a, the diameter of the projectile, is expressed in millimeters.

Mr. Vallier recognizes moreover, that this relation is still undecided; but, he adds, unless satisfied, the effects of the fire have always been very restricted in the trials made up to the present time.

We see that this relation leads to the admission that for each caliber of projectile there is a velocity limit below which the shell breaks up necessarily in attacking the face-hardened layer, and becomes in consequence incapable of passing through the plate opposed to it, whatever the thickness.

Briefly, this relation is based upon the fact that the depth of the cementation remains about constant in all cases, and grants in consequence, that the energy necessary for passing through the latter ought not to vary either.

When this first condition is satisfied, it must still be found whether the velocity of the shot is enough to ensure the perforation of the whole plate, thickness included.

This is, however, a question dependant upon the resistance of the steel employed, and one in which special consideration of cementation has in a way no place.

We should call attention in this connection to a remarkable paper on hardened plates, recently sent to the United States Naval Institute by Lieutenant Ackerman, United States Navy, which contains many quite original views. The author examines in much detail the mode of action of the shell in the attack of hardened plates, and he concludes that the face-hardened layer has especially the effect, due to its great rigidity, of causing the entire plate to contribute to the resistance, by transmitting to it instantaneously the effort which it undergoes. If this retards the progress of the projectile which stops necessarily when it meets a reaction equal to what its constitution permits it to withstand, and the part not supported in the impact hole then flies to pieces, the cemented layer would thus intervene only indirectly in the rupture.

Whatever there may be in these previsions, the accuracy of which can only be fully estimated when we have at our disposal a sufficient number of experimental shots, it is certain that the success of the last plate trials is due more than anything else to the presence of the face-hardened crust, hence had we available a type of projectiles capable of passing through the former without breaking, doubtless we should be able to obtain a perforation with less velocity. Starting from this consideration, it occured to Admiral Makaroff to provide the projectiles with a casing of soft metal covering the upper end of the ogival head; he was of the opinion that this head, breaking up on contact with the hardened crust of the plate, would thus have the effect of preventing the rupture of the shell by increasing the duration of the shock.

This rather surprising arrangement had already been tried in England, about 1883, at the time the compound metal plates made their appearance, but had then resulted in nothing satisfactory and had been abandoned.

So Admiral Makaroff took it up again last year for use against face-hardened plates, and he applied it under new conditions long held secret and even to-day only partially known. In June and July, 1894, the Russian Government had comparative tests made with projectiles of this type, the results of which were singularly remarkable and caused a tremendous sensation. Therefore we think it will be interesting to give a few details upon the subject.

These trials were made upon 6-inch (0.152 m.) shells and opposed to each other two distinct types, one having the ordinary outline of armor-piercing shell of forged steel, was made at the Putiloff Works, and the other of the special Makaroff form applied to shells of the same kind only provided with a hood of which the arrangement and outline were not divulged. Then two types of shell were tempered by a special method not previously tested and,

for purposes of comparison, three other shells tempered in the old way were made and tried.

The hood of the Makaroff shell covered the point of the ogival head, as estimated by Captain Tresidder, for a length of about 113 millimeters; it was, besides fastened to the shell by simple magnetism; which exylains the name of magnetic shell, by which these projectiles were immediately designated.

The weight of these shells varied from 41.1 kg. to 41.4 kg., exceeding that of common shell (limited to 39.8 kg.) by about 1.6 kg.

For the trial tests, three face-hardened plates 2.40 m. square were used. Two of them were planes 0.152 m. thick; one was supplied by the Cammell Works, the other by the Brown Works. The third was curvilinear and 0.254 m. thick; it came from the Brown Works also.

The two 0.152 m. plates were secured to a revolving backing made of pine timbers 0.30 m. thick rivetted with sheet iron. The 0.254 plate was in turn placed against an immovable backing of similar construction.

The plates were held in place by 12 bolts.

The velocities of the shots are noted in the table below. According to Major Vallier's figures, they vary between 550 and 570 meters for 0.152 m. plates with angles of incidence varying from normal to an inclination of 25°; for the curvilinear 0.254 m. plates the velocity varied between 663 and 714 meters, with incidences between normal and 9°.

Generally, the velocities were measured directly, but sometimes they contented themselves with estimating them from the charge of powder used.

Experiments made in Russia in June, 1894, upon four types of 0.152 projectiles against three square plates 2.40 m. each way, of Harveyized steel:

As is seen by examination of this table, the two 0.152 m. plates may be considered as comparing well with each other, since the first shots fired against each produced identical results. We next notice the striking superiority of the hooded projectiles which succeeded in piercing through the plates fired at under conditions under which the common projectiles rebounded in pieces.

The Brown plate was pierced, in fact, by normal fire, and when the incidences were 15°, 20°, and even 25°. The Cammell plate was pierced by normal fire, and when the incidence was 15°; but when the incidences were 20 and 25° the hooded projecttles hardly did much better than the common ones, the results obtained being equivalent in the two cases.

In the attack on the curvilinear plate, all the projectiles without hoods were broken, while of the three shells provided with hoods, two remained intact, and the only one which failed to go through the plate caused a very deep penetration.

It can be concluded from these trials that, in attacking plates equalling the caliber in thickness up to an incidence of 20°, and in that upon plates reaching 1.67 times the caliber up to an incidence of 10°, the hooded projectile has shown itself clearly to be superior to the common shell. This superiority would disappear with a greater incidence, because the hood then loses all efficaciousness.

This result very strange at first glance, is quite difficult to explain theoretically; however, we can consider that the rupture of the common shells in the attack upon face-hardened armor plates results above all from the fact that the action thus produced in the shock is about instantaneous. The pres-

sure of the hood on the point has the effect of giving it an appreciable duration, thus allowing the point of the ogival head to reach a softer zone while the crushing of the soft metal is going on, and undoubtedly at the same time breaking up the vibration likely to produce rupture. The projectile thus consolidated at some point next assumes an increased resistance; this would be in a word, a phenomenom analogous to certain facts, to which attention has already been called in various experimental firing tests carried on at Shoeburyness at the time the mixed metal first came out.

A compound plate, which stopped hard cast iron projectiles fired at it with a given velocity and broke them up was, however, completely perforated upon the attempt to reverse the test, by taking the soft iron backing as the face of attack. The same result was obtained by setting up a plate of soft iron in front of the compound plate in its normal position, and the projectile which would have been broken up in an attack upon a single plate, thus was made to go through the superposed ones. This result should be attributed, doubtless, to the reaction of the iron plate, which in some way supported the projectile at the moment of striking the hardened plate, thus preventing the separation of its constituent molecules; this consideration may aid in explaining to a certain extent the rather strange behavior of hooded projectiles.

According to Lieutenant Ackerman, the hood would probably work in two ways, on one hand, by decreasing the elastic action by which the hardened exterior causes the entire mass of the plate to share in the resistance. This would be, said he, an affect analogous to that observed with a flat headed projectile which should penetrate, he thinks, by a true punching action, developing an effort less than that required by the original projectile. On the other hand, the hood would intervene during the period of penetration of the projectile, preventing contact between the hard fragments of the case-hardened layer and the ogival-head itself, which, otherwise, would be broken by them.

If, on the other hand, we examine the Ochta trials from the standpoint of the resistance of tested plates, we may seek to produce from them the relation of their resistance to perforation as compared with ordinary metal when hardened projectiles are used, and we will thus find that this relation is sensibly inferior to those found habitually in the case of projectiles of ordinary type. We see, in fact, that for a thickness of 152 mm., the velocity of perforation of an isolated iron plate struck normally by hooded projectiles is 358 m., and that of a steel plate, 437.50; now, perforation was accomplished using a velocity of 560 m., that is to say with a relation of 1.56 as compared with iron, and 1.28 with ordinary steel.

The 254 mm. plate gives rise to an analogous observation: The normal velocity of perforation of the isolated iron plate is 505 m., that of the common steel plate 633 m.; now perforation was accomplished at a velocity of 727 m. at an incidence of 9°, giving a normal component of 718 m. Consequently the relation corresponding to this velocity reaches 1.40 as compared with iron, and 1.13 as compared with common steel.

Although these figures may seem already too low, it must not be forgotten that they are still too high, in reality, for we should have to take into consideration, in both cases, the backing which we have been unable to bring into the calculation of the velocity of perforation of the whole wall, not knowing exactly its composition; the relation thus obtained would be subject to an appreciable reduction.

No. of shot.	Projectile.				Plate.			Condition of the projectile.	Condition of the plate.
	Type.	Weight.	Energy.	Incidence.	Thickn's.	Kind.	Penetration.		
		kg.							
1	a	39.8	568	Normal.	.152	Brown, the grain of the plate even and quite fine, the case hardened part hardly distinguishable.	0.23	Broken. The ogive remained in plate; thirty pieces found weighing 7 kg.	Two slight cracks all the way through.
2	c	41.2	560	"	"	"	Went through.	Whole.	Pierced through. 1 slight crack. Hole regular.
3	c	"	562	15	"	"	"	Not found.	Pierced through. Hole regular.
4	a	39.8	562	15	"	"	0.175	Rebounded broken, the ogive remained in plate.	Two transversal cracks.
5	c	41.4	559	20	"	"	Went through.	Whole.	The cracks enlarged. Hole regular.
6	c	"	560	25	"	"	"	Broken. 48 pieces found weighing 13 kg.	Numerous cracks.
1	a	40	562	Normal.	"	Cammel, the grain large and brilliant, looks like burnt metal.	0.20	60 fragments found weighing 11 kg.	4 cracks, 1 all the way through.
2	c	41.2	557	"	"	"	Went through.	Broken into two pieces.	The cracks become wider. Hole regular, impact very smooth.
3	c	41.1	660	25	"	"	0.08	Rebounded broken, 184 pieces weighing 13 kg.	Four cracks, 2 all way throgh.
4	a	39.5	550	25	"	"	0.06	Rebounded broken.	Two new cracks.
5	c	41.4	550	25	"	"	0.08	. . . .	. . . .
6	c	40.1	550	20	"	"	0.08	Rebounded broken. Fifty pieces found weighing 14 kg.	Three cracks, of which two were all the way through.
7	c	40.4	550	15	"	"	Went through.	Broken.	All way through, running cracks.
1	c	40.1	714	9	.254	Brown, curved plate.	"	Broken. 6 pieces found weighing 13 kg.	Went through, no crack, interior of impact very smooth.
2	a	39.8	727	9	"	"	Not pierced.	Broken, the head remained in the impression; 11 pieces found weighing 8 kg.	No cracks. Hole irregular with many pieces.
3	c	40.4	663	Normal.	"	"	0.38	whole, remained in plate, the back projecting 2 cm.	No crack on face, *AV*, but one 125 mm. wide in rear.
4	a	39.8	669	"	"	"	0.10	Broken. Ogive remained in plate.	No cracks. Swelling 25 mm. in rear.
5	d	40.4	727	9	"	"	Went through.	Broken into two pieces.	Went through. No cracks. Hole regular.
6	c	39.8	727	9	"	"	0.29	Broken. Ogive remained in impression; 8 pieces found weighing 34 kg.	No cracks. Circular swelling 37 cm.
7	b	40	727	Normal.	"	"	0.23	17 pieces weighing 10 kg., found.	No split. Circular swelling 40 cm.

a, new temper; b, old temper; c, new temper and magnetic adaptation; d, old temper and magnetic adaptation.

We can assume, however, that the plates tested at Ochta were possibly not of first-class quality and a little lacking in hardness, which may explain, to a certain degree, the smallness of the results obtained, for the later tests in America upon capped projectiles give greater relations.

It has happened, besides that, in certain tests, projectiles of ordinary type have been able to pierce Harveyized plates, but were then moving at a much greater velocity, often exceeding by 55 per cent. that required to pierce common steel, this velocity then satisfying the relation proposed by Major Vallier as already mentioned above:

$$\frac{p\,V}{a^2} > 1.5,$$

and it is easy to see that this was not the case in the Ochta tests, for, by calculating this relation for the velocity of 718 m., we still only obtain 1.25, which would explain the inability of these projectiles to pierce, without breaking up, the hardened surface of the plate attacked.

This condition evidently no longer obtains with the hood, and so it is with any other combination by which the rupture of the projectile at the instant of striking is avoided.

The experiments at Ochta were, as pointed out above, echoed far and wide, and as soon as they were described the other maritime nations sought to penetrate the mystery still surrounding them, and on their side required comparative tests to be made with hooded projectiles more or less analogous in arrangement to those of Makaroft. In France, in particular, were tried hooded projectiles of the Holtzer and Saint-Chamond types, in which the hood, set on hot, was clamped by cooling or by crimping, and covered the ogival-head a greater or less part of its length.

In this experiment they endeavored especially, and very properly, to determine the limits of incidence beyond which the hood would lose its utility. A 24 cm. shell was fired with an incidence of 15° against a 25 cm. face-hardened steel plate, and two 16 cm. shells with an incidence of 25° against a second 25 cm. plate. The first shot was made with a velocity corresponding to the relation 1.20, with perforation of common steel; the shell rebounded broken up. In the shots made with the two 16 cm. shells, the first shell rebounded likewise broken up, while the second, broken into two pieces, was able to make its way through the plate, which was already weakened by the first shot. However, in a later test with a Holtzer hooded shell, the plate was pierced, the shell remaining whole.

These results show clearly, as we see, that it is difficult to count upon hooded projectiles unless at quite acute angles of incidence, and if we bear in mind that these oblique angles of impact are to constitute the general rule in practice, we shall recognize that the application of the hood, which has otherwise numerous objections from the standpoint of accuracy of aim, at the same time loses in this way a great part of its interest.

In America, during the fall of 1894, several experiments were also made with hooded shells, and we described some of them in the table accompanying our last paper on the tests of Harveyized plates. (See *Génie Civil* xxxviii, No. 1., p. 7.)

We will call to mind especially the trials made with 0.152 m. shell against a plate having a thickness equal to the diameter. This plate, which had by the way been rejected, owing to certain cracks, gave, on the contrary, in the

experiment, very remarkable results, and proved itself far superior to the plates tested at Ochta. In the first place, two shots were fired, May, 1894, with a velocity oi 548 m., using common projectiles, which were shivered to pieces, giving penetrations of only 0.06 and 0.08 without producing a single crack on the trial plate. The experiment was resumed in the following October: the velocity was increased to 609 m. in the two shots, Nos. 3 and 4, fired with ordinary projectiles; but the latter again broke up without passing through, giving penetration of 0.10 and 0.11. Two other shots were next fired with velocities of 548 and 579 m. with projectiles of special design, but without hoods, weighing 45.35 kg., (as did the first) and the results obtained remained analogous to the preceding ones.

A first hooded projectile weighing 48.97 kg. was then fired with a velocity of 609 m., but gave a marked deviation and struck the plate about 0.300 from the point aimed at, which brought the incidence up to 6° instead of the normal incidence sought.

This shell broke up besides without passing through, the ogival-head remaining in the impression. The next projectile, the eighth fired against the plate, was of special form, but without a hood; it was thrown with a velocity of 640 m., considered as expressive of the perforation of the Harveyized plate, and it went through effectively. Two hooded projectiles weighing 47.15 kg. were finally fired with velocities of 579 and 518 m., and both passed through; but we must take into consideration that the plate was then very much weakened by the previous shots.

Although these experiments were made with normal aim, we see that the results were far from being so remarkable as those at Ochta; on the other hand, the fire brought out certain incidents showing that the use of such projectiles was not always unattended with danger. As a matter of fact the gun was inspected after the discharge of the first hooded shell, which had given so marked a deviation, and it was found that the bore showed deep scoring in several places, situated at a distance of about 2.580 m. from the muzzle. It was supposed, therefore, that the hood had been torn off in the transit through the bore, thus brought about the wedging of the projectile and caused the subsequent irregularity found in the shot.

Yet the hood which was held in place by magnetisation as in the Russian projectiles, was at the same time secured to the base by three equidistant screws penetrating into the shell.

Such an accident, the gravity of which need not be enlarged upon, is certainly as Major Vallier remarks, of such a nature to cause us to hesitate about adopting hooded shells. It must be admitted nevertheless that this fact has not yet been observed in the firing in Russia, nor above all, in France, with the methods adopted by our constructors of using the shrinkage due to cooling; but, however that may be, a safety consideration thus arises which will doubtless prevent the use of shells of this type for a long time yet, apart from the other difficulties of every sort which they bring into shooting.

It must be noticed, in fact, that the addition of the hood has the effect of completely upsetting the tables of fire, of modifying the stability of the shell in its trajectory, and, consequently, of marring the precision of the fire; and Captain Sampson, U. S. N., tells us on his part, in the work previously described by us, that the use of these shells is in no way practicable.

If we consider on the other hand that they lose all their efficacy in oblique fire with high incidence, which would be the only kind used against armored

vessels, we will admit that face-hardened plates have little to fear from the entry of this new adversary into the lists, and we may conclude that the never ending struggle between projectile and armor is not yet on the eve of ceasing, owing to the final overwhelming of one of the opposing contestants.

Competent judges believe, in fact, that the protective armor of the war vessels built at the present time surpasses the artillery in use, as the Minister of the Austrian Navy was able to state before a parliamentary commission at a meeting held June 15th, last.

He was able to add, besides, that armor had equally little to fear from the use of the explosives sought to be used against it in addition to armor piercing shells, for projectiles filled with melenite or pyroxylin had not given, he said, favorable results, either from the standpoint of range, or of accuracy of aim.

L. Bacle,
Late pupil at the Ecole Polytechnique,
Civil Engineer of Mines.

[Translated by Captain G. G. Greenough, 4th Artillery.]

b. Armor and Projectiles.

Ballistic Test of Reforged Armor Plate for the Russia.

The continued progress made in the manufacture of armor in this country by the Carnegie Steel Company, Limited, is well illustrated by the engravings we present this week of the results of the ballistic test of the last Russian trial plate for the Russian armored cruiser *Russia*, tested at the naval proving ground at Indian Head, May 13, 1896.

The tough, hard armor manufactured by the Carnegie Company under the patent of W. S. Corey represents the latest development in the manufacture of American armor plate. The combination of the qualities of toughness and hardness is obtained as the result of special chemical composition, work, super-carbonization, reforging and water hardening. The final operation is the actual face hardening (frequently called tempering), and it consists in the sudden application of a suitable cold liquid.

The plate in question was 16 feet long, 8 feet wide, and tapered from 8 to 4 inches in thickness; and was of nickel steel, face hardened and reforged. It was attached by bolts in the usual manner to a wood backing and was attacked in rapid succession by five 6-inch and three 4-inch Holtzer armor-piercing shell fired at high velocities, the 4-inch projectiles being fired only against the thinnest section of the plate.

The requirements of the test were that four 6-inch projectiles fired at striking velocities of 1,856 foot-seconds, and four 4-inch shell at striking velocities of 1,926 foot-seconds, should not get entirely through the plate and backing nor crack the plate sufficiently for any portion of it to leave the backing.

Owing to the very great irregularity of the Dupont brown powder employed, the velocity of the third shot was so much below that required that an additional 6-inch projectile was fired at the point marked No. 5, very near to impacts Nos. 1 and 2. But as the plate stood up so well under its repeated battering, the fourth 4-inch shot was waived.

The projectiles were fired in such quick succession that the stresses caused thereby must have seriously taxed the plate. This method of test would certainly discover any lack of uniformity in the plate, while its ability to keep out and completely pulverize a 6-inch Holtzer shell when fired at a striking

velocity of 2,149 foot seconds showed what splendid ballistic resistance it possessed.

The proximity of the points of impact to the edges and corners of the plate and to each other; the number, rapidity of attack and high velocities of the projectiles; subjected the plate to such an unusual test that General Mertwago, the president of the Russian inspection commission in the United States, recommended that the remaining armor under manufacture by the Carnegie Company be accepted without further test, which recommendation the Russian government unhesitatingly granted.

In fact there seems to be no doubt that the plate would have kept out any projectile of a caliber equal to the thickness of the plate at the point of impact if fired at service velocities. This certainly is an excellent protection for any ship. Both Russia and the Carnegie Company are to be congratulated.

The following table gives the details of the test:

Impact No.	Projectile, Holtzer, caliber inches.	Striking velocity, foot seconds.	Striking energy, foot tons.	Estimated penetration, inches.	Condition of projectile.	Condition of plate.
1	6	1887	2484	5	Broke up.	No cracks.
2	6	1826	2311	5	"	"
3	6	1886	2480	5	"	"
4	6	1846	2362	6	"	"
5	6	1866	2413	6	"	"
6	4	1991	907	2	"	"
7	4	1958	877	2	"	"
8	4	1959	878	2	"	"
9*	6	2149	3221	7	"	"

* This round fired at the request of the Carnegie Company, the group of armor having been accepted after the eighth shot.

—*Scientific American*, July 4, 1896.

Herr Krupp on the Perforation of Steel Armor.

The investigation of the laws of perforating armor-plates at high velocities has not been satisfactorily attempted. Artillerists have had to content themselves in all countries with empirical formulæ based on fragmentary evidence. For this, no doubt, obvious reasons may be urged. It may be said, first, that the plates often fracture, and so far the form of work done is changed, and still worse that the shot break, that the trials are very costly and must be confined to the immediate object in view, and hence isolated results are obtained which do not lend themselves to the formation of series. The answer to all this is that the question could be investigated on a miniature scale, which would cost comparatively little, and so laws might be suggested such as would admit of verification by any trials which might take place on a large scale. We believe ourselves that almost all laws on such questions are thus established, and both on this and on the other side of the Atlantic the cry has been raised for something to be attempted, though hitherto without success. So far as we are aware, we all run very much in

Plate in position for test.

Front face of plate after test.

Rear face of plate after removal from backing.

Front face of backing after test.—Plate removed.

the same groove, and it is a curious spectacle. At Meppen, in a solemn German manner, is tried year after year how certain individual German plates behave under the attack of big German projectiles which will never be fired at these on service. At Gâvre, French shot make an animated onslaught on French armor. At Portsmouth or Shoeburyness, British projectiles attack British plates. At Indian Head, the United States projectiles of Carpenter and Wheeler-Sterling prove their powers on Carnegie and Bethlehem armor. Rarely, indeed, is a plate attacked by any shot representing those which it could in any reasonable likelihood encounter in war. At one time Holtzer's shot were much used and formed a sort of international standard of comparison, but latterly this seems to have dropped out. Russia and some other Powers, from ordering armor abroad, have brought the shot and armor of different countries into comparison occasionally; but generally speaking it might be supposed that each nation was mainly interested in isolated facts connected with the attack of her own plates by her own shot, and did not care to obtain more general information, either by experiment or by the establishment of laws and formulæ. In this condition of things, it is curious to note how such individual efforts as are made bring out similar results, though sometimes masked in the different shapes assumed, and by the use of different systems of units. In our issue of April 24th last we pointed out how similar are two formulæ proposed by Krupp and Tresidder, the real difference being that in the former weight tells more than in the latter. It may be seen below that with projectiles of the same weight the formulæ become identical. Thus, written in British units, Krupp's formula is

$$t^{\frac{4}{3}} = \frac{w v^2}{d^{\frac{5}{3}}} \times \frac{1}{\log^{-1} 5.7776}$$

and Tresidder's $t^2 = \dfrac{w v^3}{d} \times \dfrac{1}{\log^{-1} 8.8410}$.

We may disregard all the constant factors, or allow them to flow, as it were, into one term, whose value will be determined once for all in practice. Taking Krupp's formula and raising it to the power $\frac{3}{2}$, we get $t^2 = \dfrac{w^{\frac{3}{2}} v^3}{d^{\frac{5}{2}}} \times$ constant term. Next, supposing we are dealing with shot of similar form, it follows that the wei ht will be in proportion to the cube of the diameter, that is, for w we may substitute $d^3 \times$ some constant; applying this to Krupp's as we now have it, and to Tresidder's, we get in each case $t^2 = d^2 v^2 \times$ some constant; that is, they become identical, the sole difference between them having disappeared.

This is a little remarkable, having probably never been intended, and the two formulæ having looked unlike in their original shape. We have, perhaps, a more striking instance of agreement in the case of a formula recently propounded by Krupp for use with the best and newest steel plates with hardened faces. This is taken from the translation of an article by Captain J. Castner, in *Stahl und Eisen* of April 1st, 1896. In continental units this is given as $p v^2 = 5800\, a\, E^2$, where v is the striking velocity in meters, p the weight of projectile in kilos., a the diameter of projectile in cm., and E the thickness of the plate in cm. Turning this into English units and transposing, we get,

$$t^2 = \frac{w v^2}{d} \times \left\{ \frac{(0.3937)^3}{2.2046 \times (3.2809)^2 \times 5800} \right\}$$

which worked out by logarithms for a single constant becomes

$$t^2 = \frac{wv^2}{d} \times \frac{1}{\log^{-1} 6.3532}.$$

This is said to have been first laid down at the Krupp Works, which may be true as applied to steel with a hardened face, but certainly is the oldest and simplest form of Fairbairn's equation, and the one on which a rule-of-thumb was based many years ago, as explained in the "Official Text-Book on Armor and its attack," page 30, 31. This rule-of-thumb was then applied to wrought-iron and give the best results, when the sectional density of the shot was such that $\frac{w}{d^3} = 0.41$, and when the striking velocity was not veiy far removed from 2000 foot-seconds. According to Krupp, we may now take it as based on the best formula that can at present be suggested, and we find the average $\frac{w}{d^3}$ for the six first armor-piercing calibers of Krupp's which we take is 0.42, while for thirteen British it is 0.45. The striking velocity on service for heavier guns would probably not be very far removed from 2000 foot-seconds; so that a fairly sound rule-of-thumb ought to follow—depending on the constant—and this turns out such that we may say, approximately speaking of steel plates with hardened faces, 2000 foot-seconds striking velocity will give about the caliber perforation, and other velocities proportionately. Thus a 6-inch shot with 2000 foot-seconds may perforate 6-inch treated steel; with 1500 foot-seconds it may perforate 4½-inch; with 1000 it may perforate 3-inch, and so on. This amounts to putting the best steel equal to twice the thickness of wrought-iron. In the absence of more trustworthy data this may be useful, but we need hardly say that it is only suggested, not at all established. It is possible that the hard-faced armor of the present day may crush less and tear more truly and completely than softer metal, and this suits the old formula, but with armor depending on its power to fracture the shot's point, and with shots at all broken, great elements of uncertainty must exist, and we are brought back to our need of systematic experiment in order to obtain any certainty.

—*The Engineer*, July 3, 1896.

c. Powder.

* * * * * *

d. Torpedoes.

* * * * * *

e. Range and Position Finders.

Range Finding.

The necessity of range and position finding has been but little recognized in our service owing to the non-supply of instruments and no established scheme of instruction. Most of the army firing takes place over known distances or such as can be easily compared with them: the conditions of actual warfare are therefore to a great extent neglected. At this post, where such splendid opportunities exist for unknown distance practice, the target firing is rapidly advancing to that condition which benefits most. It certainly would be a bitter disappointment to a gunner if he come to energetic warfare and found that his fire, apparently so deadly at home, proved harmless at the very time when it is a matter of life and death that it should be effective. When dummies are put up as targets on broken unknown ground, the

men soon find how powerless they are to make effective practice unless the distance be truly or very approximately estimated, so they take keen interest in the training of the eye and will readily tolerate the use of an instrument to help them out of their difficulty. The artillery service is laboring under the disadvantage of limited ammunition supplies and the idea must be to make the best use of all expended—indeed this very disadvantage should lead us to carefully consider the finding of our ranges.

Anyone who has seriously tried to estimate distances must have found how difficult it is to do with even approximate accuracy on familiar ground and at short ranges. In a strange country and at larger ranges the unaided eye is so unreliable as to often give results almost useless for practical purposes,—hence the adoption of the range finder.

The advantages gained by introducing into any arm an efficient system of range finding include the following:

1. A demoralizing effect on the enemy by a fire efficient from its beginning.
2. A steadying effect on our own men.
3. A check on reckless expenditure of ammunition.
4. A consequent saving in transport.

But the distribution of a few range finders to the army without any organized party or system of training is of no use whatever. The opinion of officers of high standing and of great practical experience is, that the power of the artillery may be enormously increased by the habitual use of range finders in the hands of properly trained men. Unless, then, some such system is established, we may be left hopelessly behind other nations who are devoting care and attention to the subject.

There are two classes of instruments used, the *range* finder gives the distance from itself to the object sighted; the *position* finder marks on a plan the exact position of the object and thus gives the range to any and every point marked on the plan. I will not even *name* the various instruments that ingenious people have invented, but I must allude to some of their principles and characteristics.

The successful range finder must be simple, small, cheap—and of course, *accurate*.

As to their utility, we may consider them in two classes:

1. Those available for infantry and field artillery.
2. Those available for coast artillery.

As you all know, their principles are various. We have:

1. Those utilizing the velocity of sound in air—Telemeters, stop-watches.
2. Those utilizing the known height or length of distant objects—Stadiometer, Elliot, Labbez.
3. Those using triangulation. Short fixed base—Clerk, Guthrie, Odie, Berdan.
4. Those using a base of fixed or variable length—Nolan, Weldon, Gautier, Paschwitz, Pratt, Watkins, Gordon, etc.

All of these instruments are fully explained in text books and the *Journal of the United States Artillery* No. 13. I have some drawings here representing a few of simple design. The Souchier, a flat pentagonal prism of glass, and the Paschwitz, are both very simple in design and working. It is said the Weldon is most accurate at longer ranges—error not over 2%.

It is not my purpose to enlarge upon any range finder or system of finding

ranges. The English service devotes much care to the subject, having regularly enlisted range takers who receive extra pay. The Germans depend almost exclusively upon the fork found by actual firings.

Paragraph 645 Light Artillery Drill Regulations requires that "all the non-commissioned officers and some of the most intelligent men of each section should be practiced in the use of the authorized range finder; those that show the most aptitude should continue the practice until they become expert; from these last, a range finding party can be permanently detailed when the battery takes the field. Instruction should also be given in judging distances by sight."—Evidently we must confine ourselves to the last part of this general injunction. The Board appointed in this battalion is quietly and modestly pursuing its way with the exceedingly few instruments sent to them for test, I believe, so I cannot say how near the field artillery is to receiving "the adopted United States Range Finder."

We have means, however, for drilling in the estimation of distances and such instruction, combined with the use of our sight as a range finder, should be carried out in order to have a battery properly equipped for immediate active duty. I advocate therefore, practice and instruction in the estimation of distances, practice makes perfect, and a method can be adopted just as in sea coast batteries, for the purpose of discovering what each man's personal error may be in judging ranges. The odometers supplied to the batteries can be used to obtain the correct distances; or even measurements with tapes would be of value, provided the men prone to a constant error either beyond or short could be thus brought to recognize their personal error and correct accordingly. Estimating ranges is an essential part of the instruction of every battery, and since in the excitement of action the employment of instruments is very difficult, it is desirable that all the officers and men should be able to judge distances by the eye. Under conditions favorable to observation long practice enables an observer to estimate immediately and quite closely the position of an object within familiar ranges. Beyond 500 yards, the variable conditions of the atmosphere as well as the form and nature of the ground lead the most practiced observer often into considerable error. A knowledge of the parts of objects visible at certain distances is necessary, but as this will vary with the power of the eye, each must, by comparison and reflection, establish a standard of his own.

We have well drilled into our minds the importance of knowing the correct range when a battery opens fire, so cover should be used by the range finding party in order that they may not attract the enemy's attention to the position a battery is to occupy. The party should always precede the battery if practicable keeping in communication with the battery commander.

Every light battery should have its own range takers and I know of no better men for that purpose than those with whom we are all familiar. In every battery there are some men of keen intelligence and quickness, who yet never reach the *non-commissioned* roster: it may be they are slouchy or lazy, slovenly in dress, given to intoxicants, lack sufficient force or have some other greater or less impediment—some even decline the honor. Three such men would take great pride in being among the "range takers" of the battery and I have no doubt would be the men to rely upon when warfare is a reality and not a history. Indeed the position is of such importance that I believe the enlisted strength of a light battery ought to include "range takers, 3" with increased pay above a private. Good eyesight is of prime

importance. A battery in action is rarely subdivided more than once and if the battery range takers consisted of one officer, two non-commissioned officers and the three privates mentioned, the party could be easily split to suit such an emergency. Frequent practice in the estimation of distances and range taking under cover should form a great part of the instruction of this party. They should be taught the following rules which good sight admits of:

1. Counting the windows of a house at 4,300 yards.
2. Perceiving men and horses at 2,200 yards.
3. Distinguishing clearly infantry at 1,800 yards.
4. Seeing the movements of men at 800 yards, etc.

Objects always appear too near when seen distinctly outlined against a bright background and when the observer has the sun at his back, or when the air is particularly clear, as after a rain. Distances are underestimated also when the ground is uniform and offers no prominent points for reference. On the contrary, objects appear too remote when obscure and indistinct. This occurs if the sun be in one's face and if the weather be cloudy or foggy. Distances are also overestimated when the ground is undulating, cut by ravines, or covered by trees or dwellings.

In determining ranges in the field, when time is abundant, accuracy should be insured by deliberate work and verification by taking more than one observation to a particular point. This will generally be possible on the defensive when the range should be taken to all points which may become important during the course of the operations, and recorded. When time is scant, the range takers must attend closely on the commanding officer in readiness to find the range as soon as he can point out the intended position for action, and if a base be used it should be to windward of the guns and within easy communication. Ranges to positions in advance or rear may be easily judged by subtraction or addition. Some ranges to moving objects cannot generally be taken, points must be selected in their path, sufficiently advanced to permit time for operation. Observers must be careful to direct the instrument on exactly the same spot each time during one range taking, as a failure to do so entails certain error. When the target cannot be directly seen, an adjacent object may be taken, but this fact should be reported to the battery commander, since often targets apparently equally distant are not so in reality.

The method of finding the unknown range last year by three percussion shell in five minutes proved satisfactory, yet for accurate firing at an opposing enemy, modified of course by the circumstances, the long and short bracket system should be used. Suppose, for instance, the range has been estimated,—a shell is fired with the proper elevation for this range and the burst on striking is carefully noted. If the first round fall short, the elevation is increased to correspond to about one-tenth of the range, if estimated, or one-twentieth if taken with the range finder and if the next shot fall short, the elevation is again increased by the same amount, the operation being continued until a round is observed to burst beyond the target.

The two consecutive rounds falling short of and beyond the target give what is termed the *long bracket.*

If the first shot bursts beyond the target, the long bracket is obtained by corresponding successive diminutions of the elevation until a shell bursts short of the target.

The long bracket having been found, its mean is then taken and a round fired with the corresponding elevation. Then the mean of this range and the one of the long bracket nearer to it is taken, and a shot fired with a corresponding elevation, and so on until the target is enclosed between two consecutive rounds only *fifty yards* apart, which constitute the *short bracket.* The mean of the short bracket can then be taken as a close approximation to the correct range.

The subject of range finding is one of paramount importance to us all, for if our new sight should happily be furnished with the slide graduated in yards, an accurate estimate of the range at once gives a battery a superiority unthreatened by delays due to the examination of columns of figures and degrees. The question of the supply of ammunition will also be simplified with a correct knowledge of the range. In action the efficacy of fire depends more on the range being known than on individual skill. With range unknown or miscalculated, the best gunner may miss the mark; with range known the poorest is liable to do effective shooting.

Instruction in drill that will improve a battery's efficiency in the matter of ranging or range finding is therefore of utmost importance, if it is intended to have that battery in best condition for deadly service, and this does not depend upon paint, polish or niceties of precision.

Since this was written, the Government has adopted sights marked in "yards" for the field piece, therefore the greatest necessity exists for careful instruction in finding the range.

T. N. HORN, 2d Lieutenant, 2d Artillery.

f. Miscellaneous.

Tensile Tests of Cast Steel.

Below is published a table showing the result of tensile tests of fifteen specimens of cast steel. These castings were made by the American Steel Casting Company of Thurlow, Pa., for use in the Buffington-Crozier disappearing carriages, being built for the Ordnance Department of the United States

Steel Castings made by the American Steel Casting Company, for the Ordnance Department, U.S.A.—Tensile Tests.

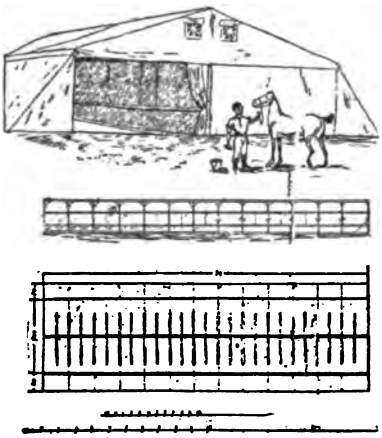
Elastic limit. Pounds per square inch.	Tensile strength. Pounds per square inch.	Elongation after rupture. Per cent.	Reduction of area after rupture. Per cent.
30,000	67,000	28.8	46.3
32,000	68,500	29.0	47.8
30,500	67,000	30.6	52.8
30,500	70,500	28.8	41.0
33,500	72,500	27.2	42.5
30,500	65,500	29.8	44.9
30,000	65,000	30.5	54.1
32,000	69,500	27.0	48.6
29,000	65,000	26.0	50.0
30,000	65,000	30.2	51.1
30,000	68,500	38.3	42.2
30,000	65,500	26.0	50.9
33,500	68,500	34.3	43.7
29,500	66,500	29.2	48.0
32,500	69,000	28.0	41.9

Army. The results would be remarkable for the best forgings, and for steel castings they are considered by experts as really extraordinary. The figures published are duplicates of those which appear on the report of Captain D.A. Lyle, Ordnance Department, United States Army; and Captain Lyle, in signing the report, offers his congratulations. The results here shown cover castings produced from five different heats, indicating remarkable uniformity. The length of stem of the test piece was two inches, and in each case the fracture is noted as silky, and all of the specimens were accepted.

—*The Railway Review.*

A Shelter Tent as a Stable.

The *Belgique Militaire* publishes some interesting information in regard to a new stable tent, made by the Gottschalk firm of Cassel for the German cavalry. We borrow from our esteemed contemporary the following description and sketch:



The accompanying sketch of the tent allows us to abbreviate the description. This tent accommodates 52 men and 52 horses, and is provided with all the necessary bars, mangers, saddle hooks and the like accessories. The distance between the middle posts and the side posts is 4.5 meters (15 feet); of this, 2.5 meters (8 feet) is reserved for the horse, and the other 2 meters (7 feet) is a passage way. There is a space 2 meters (7 feet) wide between the side posts and the tent wall, used by the trooper for sleeping and for storing his equipments.

The tent can be put up in four hours and taken down in two; from four to six men are sufficient for this. The tent weighs 4800 kilograms (11000 lbs.) and may be transported by wagons or by railroad. The Germans use the latter mode of transport.

This kind of tent is used in Germany in all the cavalry maneuvers, and in the maneuvers of other troops. Two hundred of these tents have recently been delivered at Berlin and at Dresden.

The advantages of this mode of encampment are active and ready supervision; perfect ventilation for men and horses; a quickly set up and inexpensive form of lodging; facility with which the tents can be supplied, and finally the tactical units are grouped in distinct spaces.

We know that the Germans are determined to make their cavalry, armed with the lance, play a part similar to that of the Napoleonic cavalry.

Emperor William not long ago led a charge of sixty squadrons. Hence concentration becomes necessary and concentration becomes bivouacking. The cavalry of the First Empire always bivouacked; so does the modern German cavalry at the grand maneuvers.

Cantonment has been cried up so much simply because the Germans made use of it in 1870-71; but at that period the German cavalry could disperse without suffering in consequence, since the French cavalry was inactive, being held in reserve behind the army corps.

In Belgium, the observation of our frontiers imposes on us the necessity of concentration. At least one brigade of each division besides horse artillery, will have to remain concentrated at a favorable point (Tougres for the first division; Ath for the second division). But to effect concentration the farmsteads can hardly be utilized; hence bivouacking will be necessary for some units and the tent proposed will be very useful.

However it is important that local resources should be made use of as far as possible and that the impedimenta should not be increased. Hence on this account, we estimate that it will be sufficient to provide shelters for four regiments (two in each division). The distribution might be made by the divisional staff. The usefulness of this tent in the maneuvers is very evident.

In general, our country offers the necessary lodgings for the troops that take part in the grand maneuvers, although in our last maneuvers this tent might have been employed to advantage for the cavalry. Our papers pointed out that the horses were not properly sheltered at the farm houses.

We call the attention of the authorities to this method of lodging both horse and man. To govern rightly it is necessary to look ahead, and if our army is to cover our frontier successfully, it goes without question that the troops must bivouac. The climate of our country hardly permits of the soldier sleeping in the open air, and hence tents become a necessity.

—*Revue de Cavalerie*, January.

[Trans. G. B.]

Aluminum Horseshoes.

The question of preparing horseshoes from aluminum has been carefully studied by Mr. Japy in his works at Beaucourt; and on these experiments Mr. Reiler made a report to the National Society of Agriculture of France, from which the following facts are extracted.

The aluminum shoe has only about one-fourth the weight of the iron one; even with an alloy of 10% of some other metal, added for the purpose of giving greater hardness and durability, the entire set of shoes for a horse does not weigh any more than one ordinary iron shoe for a hind foot; this diminution in weight the horses themselves feel at once, so that when they first come out of the blacksmith shop they walk as they do when unshod, and as if they were afraid to put their feet on the ground. According to measurements made it appears that as the hoof grows the shoe gradually opens, so that after from thirty to sixty days the heels are from two to three millimeters farther apart than when first put on: the shoe, therefore, adjusts itself to the growth of the hoof, and will probably in many cases prevent lameness, or be of good service in the treatment of diseases. A shoe of this kind lasts from forty to sixty days, depending on the particular alloy used and the amount and character of the work the horses are required to do: but the data here given are not always as reliable as might be expected, because even the slightest carelessness in the preparation may considerably alter the durability.

Mr. Japy experimented with the following alloys:

1. Pure aluminum, tenacity 19.79 kg. to 1 mm^2.
2. 85% aluminum, 15% tin, tenacity 20.30 kg. to 1 mm^2.
3. 94% aluminum, 6% copper, tenacity 24.50 kg. to 1 mm^2.
4. 90% aluminum, 10% of an alloy of copper containing 33% nickel, tenacity 30.50 kg. to 1 mm^2.

All the shoes cast of these compositions broke like glass. The following method was then adopted: The alloys were rolled in plates of three times the required thickness of the shoes; the plates (in the cold state) were then cut, and afterward pressed to increase their hardness and give them the required thickness; the shoe was at the same time finished (with nail holes, etc.). An improper temperature in the heating may reduce the tenacity thirty or even forty per cent.

The shoe is put on in the cold state, of course. If it does not fit it must be re-heated. But in this process, as before remarked, it is necessary to exercise the greatest care in order to obtain the proper degree of hardness; if special furnaces are not available for this purpose, it may be accomplished by repeatedly laying the shoe on an iron plate heated to redness. The nails must fit accurately into the holes, otherwise the constant jarring might cause them to cut deeper and deeper into the shoe.

On removing a shoe of this kind it was found that between the shoe and the hoof a white layer, about 1 mm. thick, had formed, which weighed about 2.5 grams, and which was the more abundant the more nearly the alloy approached pure aluminum in composition. Examination proved it to be an aluminum salt, mixed with about 33% of organic matter; but it is not yet known whether the formation of this layer on the surface between shoe and hoof is caused by the perspiration from the foot or by stable vapors. In any event it would be advantageous to prevent this evil, if possible, for example, by coating the shoe before putting it on with a layer of caoutchouc previously softened in warm water.

The alloy with copper-nickel proved the best.

Mr. Japy comes to the conclusion that aluminum shoes may possibly be applicable to race horses and fancy horses, and that they may be very useful in the treatment of certain diseases of the hoof; but only men experienced in working with aluminum should undertake the shoeing. On the other hand, these shoes cannot be recommended for horses which have much work to do, or which, like cavalry horses, must be prepared for hard service.

Mr. Lavalord made similar experiments and rejects these shoes on the ground that they are not economical, since they wear out faster than the iron ones, moreover, they cannot be used over again.

—*Schweizerische Zeitschrift für Artillerie und Genie*, December, 1895.

[J. P. W.]

Further Experiments With Aluminium.

Notwithstanding the distrust which has recently been created by the results of recent experiments in Germany and elsewhere, we understand that the French War Office has recently ordered the use of aluminium drinking and mess vessels for the army. It is stipulated that these shall be beaten up from plate, and that no solder whatever shall be used in their manufacture. The event has called forth a statement from M. Balland, who recently communicated a paper to the Paris Academy of Science. He says that similar vessels to those which have been ordered for the French army vary in weight by from

4 to 9 per cent of the total, and he attributes this to the solvent action of the soda baths which are used to clean the surface of the manufactured vessel. The vessels resist well in ordinary use, mechanical wear and tear, and the action of fire, foods, and cooking liquids which are not in contact with the metal for long periods. Water left in these vessels for some months gives rise to flocculent deposits of alumina. These seem always due to particles of foreign substances in the metal, and appear especially in the neighborhood of the rivets, which fasten the handles, and which are made of alloys of aluminium. The loss of weight in this way during six months was less than 0.1 per cent. Sheets of aluminium used in Balland's previous researches, and bottled up with Seine water for four years, became covered with a hard skin, dissolved off by 1 per cent sulphuric acid, leaving a bright surface, and causing a loss of weight of about 3 per cent. Salt water, of 35 grms. to the litre, acted like ordinary water, but to a much greater extent. The rivets become loose, and the handles come off. Except where the nodules of alumina are, a blackish rough skin forms, which sand will not bring off, but which yields to 24 hours' soaking in 1 per cent sulphuric acid. The loss of weight in four months, through corrosion by the salt water, was about 0.6 per cent. This communication may be found *in extenso* in the *Comptes Rendus* 121, pages 381—383.

—*Electrical Review*, June 5, 1896.

WAR SHIPS AND TORPEDO BOATS.

The Argentine Cruiser "Garibaldi."

The *Garibaldi*, illustrated on page 50, is a twin-screw armored cruiser of 6,840 tons displacement, built originally for the Italian Government by the well-known firm of Messrs. Gio. Ansaldo & Co., of Sestri Ponento and of Sampierdarena, the principle marine engine and ship builders in Italy. The vessel was designed by Comm. E. Masdea, now Director-in-Chief of Naval Construction. The vessel, however, was completed considerably within the time allowed by the contract, being finished ready for sea within 11 weeks from the date of the launch. With the consent of the Italian Government, the *Garibaldi* was sold by Messrs. Ansaldo to the Argentine Republic, the firm agreeing to construct another vessel similar to the first, but having Belleville water-tube boilers instead of cylindrical, as fitted in the original ship, and to deliver the second vessel complete by the time agreed upon for the first ship.

The armament consists of two 25-centimetre and the following quick-firing guns: Ten 15-centimetre, six 12-centimetre, ten 57-millimetre, ten 37-millimetre, two machine, and two light guns.

The leading dimensions are: Length, 328 ft., 1 in.; extreme breadth, 59 ft. 9 in.; draught, 23 ft. 3 in., at which the displacement is 6,840 tons.

The engines, which are of 13,000 indicated horsepower, constructed by the same firm, from drawings and technical assistance furnished by Messrs. Maudslay, Sons, and Field, Limited, London, consist of two sets of triple-expansion inverted engines having cylinders 42 in., 63 in., and 93 in. in diameter respectively, with a stroke of 3 ft. 10 in. Each cylinder is supported by four cast-steel columns with cast-iron cross-head guides bolted on their faces, and standing on cast-steel main bearing frames. The high-pressure cylinders are fitted with piston valves, while the intermediate and low have double-ported slide valves, all being worked by double eccentric and Stephenson's link motion. The piston-rods, connecting-rods, and shafts are of steel, the crankshaft being made in three parts interchangeable. The condensers, two

in number, are of delta metal, and are fitted with horizontal tubes through which the cooling water passes, and have a cooling surface of 14,600 square feet. There are two single-acting air pumps made of gun-metal, 33 in. in diameter and 21 in. stroke, worked by beams from the low-pressure cylinder crossheads. For the purpose of keeping a vacuum in the condensers while the main engines are at rest, each of the circulating pumps, which are worked by independent compound engines, is fitted with a small auxiliary single-acting air pump. These pumps draw from the condensers and deliver into the feed tanks. The propellers are of gun-metal, each having four loose blades bolted on to the boss, the pitch being made adjustable from 21 ft. to 25 ft.

Steam is supplied by eight single-ended cylindrical boilers 15 ft. 2½ in. in diameter and 9 ft. 11 in. long, working at a pressure of 155 pounds per square inch. Each boiler is fitted with four corrugated furnaces 3 ft. 6 in. in diameter and 7 ft. 4 in. long, and two separate combustion chambers. The total area of firegrate is 775 square feet, and the heating surface is 21,500 ft. The tubes are 2½ in. in diameter, and are fitted with ferrules at the combustion chamber end. There are two funnels 8 ft. in diameter and 80 ft. high.

The speed is 20 knots, and the coal capacity 600 tons.

—*Engineering*, July 10, 1896.

MILITARY GEOGRAPHY.

Engineering as Exhibited on the Great Lakes.*

Dimensions of the Great Lakes.—These bodies of water are truly "Great Lakes," and great engineering achievements are associated with them. Few realize that the bulk of the immense traffic of the Great Lakes (a traffic in volume in advance of any navigation with which we are familar in Philadelphia) is carried on at levels of from 573 to 602 feet above tide, and that the 3,000 craft which form the lake marine west of Buffalo float at heights of from 10 feet above to 19 below the crown of the hat of the statue of William Penn on the top of the Philadelphia City Hall. We are familiar with the expression "Great Lakes," but do not appreciate their magnitude.

Starting at Duluth, a vessel of moderate size would, at present, after traversing 1,300 miles, passing *en route* the Sault Ste. Marie, the Welland and the St. Lawrence Canals, practically reach tide level at Montreal (which is 25 feet above the sea), and still be nearly 1,000 miles from the Atlantic Ocean.

Lake Superior, as above indicated, is 602 feet above tide, and is, therefore, the highest as well as the largest and deepest of the lakes; in fact, it is the largest known body of fresh water, its maximum depth being 978 feet; the bottom is nearly 400 feet below ocean level, and at ocean level its area would be between 10,000 and 15,000 square miles. But Lake Superior is not alone in this particular, for Lake Michigan and Lake Huron, whose surfaces are 581 feet above the ocean, have maximum depths of 870 and 702 feet respectively, and Lake Ontario, 247 feet above tide, is 678 feet deep.

The waters of Lake Superior reach the level of Lakes Huron and Michigan through the St. Mary River. where about 90,000 cubic feet of water per second dash over the rapids. To overcome this difference in elevation (18 feet), locks have been constructed at the Sault Ste. Marie, in connection with a canal about 1 mile long, of which mention will be made later.

Harbor Improvement—Lake Superior.—The work of the engineer is evident

* A lecture delivered before the Franklin Institute, December 6, 1895.
The lecture was liberally illustrated by a large number of lantern slides.

at Duluth, Superior, Ashland, Marquette and elsewhere, where railroad lines terminate on the upper lakes in enormous grain elevators, flour and lumber mills of great capacity, and representing advanced construction and equipment, while the harbor improvements on the Great Lakes have demanded large outlays of money and the highest engineering skill.

In this connection, the canal entry at Duluth, is interesting as indicative of the progressive spirit of a people determined to attain commercial advancement. Minnesota Point, a long sand spit or peninsula, extends for some 7 miles from near the business center of Duluth to a natural entry opposite Superior, Wisconsin, and is the last of a series of visible bars formed by detrital matter brought down the St. Louis River, meeting the wave action of the lake. The Duluth entry was cut through the peninsula, and is of interest as a problem in harbor improvement, which, up to the present time, has failed to exert the baneful influence which skilled engineers prophesied. A vessel buffetted by severe storms may in a few moments, by means of this short canal, pass from the tempest-tossed waters of Lake Superior into the calm surface of the commodious harbor, known as Superior Bay.

At Marquette, Mich., there is being constructed a breakwater 3,000 feet in length, composed of béton blocks, under the personal direction of Mr. Clarence Coleman, U. S. Assistant Engineer, from plans prepared by Major Sears, U. S. A. The blocks (each one weighing 100 tons) form an entire section of the breakwater, 10 feet in length, and are monoliths, moulded in place on a Portland cement subaqueous foundation. The stone used is a hard quartzite, broken to 2-inch and 1¼-inch sizes. The mortar was made of Portland cement for all subaqueous work, and with natural cement for the blocks, mixed with coarse, water-washed sand, obtained from the shores of Lake Superior. The concrete base, 2 feet thick, rests upon the crib work of the old breakwater, burlap being spread upon the filling stone in the cribs to receive the Portland cement concrete and prevent undue wash from the bottom. Upon the subaqueous work is constructed the monolithic béton blocks, which are moulded in alternate sections of 10 feet in their longitudinal direction, the intervening spaces of 10 feet between the blocks being subsequently filled in by special forms, making the whole structure continuous. Horizontal planes of weakness are avoided by completing a block without any intermission in depositing concrete when work has once commenced. Vertical planes are created by moulding in sections of 10 feet, so that any settlement which may happen in the crib work will only affect the block under which it may occur; and by cushions of tarred paper, placed between the blocks, it is expected to avoid the consequences of contraction and expansion in the mass of concrete.

The breakwater has a base of 28 feet in width of Portland concrete, and 23 feet base for the monolithic block, which shows 9 feet 3 inches above the Portland cement base on the harbor side. The gallery, which extends for the entire length of the structure, is intended to be used in giving the keeper access to the harbor light on the outer end of the breakwater during heavy storms.

It will be understood that the structure is intended to be used solely as a breakwater, and is not in any sense a pier for the convenience of vessels.

Lake Michigan.—Although but few of the points of engineering interest in the Lake Superior region have been indicated, attention may now be devoted to two specialties on Lake Michigan, which also abounds in notable works.

Chicago, a great city built up from low ground, alone presents a long array; her water supply and sewage disposition, her harbor, her numerous bridges, her river tunnels, her network of railroads, her great industries, her iron and steel manufacture, now rivalling that of Pittsburgh, Pa., all represent advanced engineering science. It is authoritatively stated that in the season of navigation more tons of freight go from Chicago eastward by water than by rail, a large proportion of the lake fleet prorating with the railways at Erie, Cleveland, Buffalo, etc. In this arrangement the rate by boat per ton mile is about one-fifth to one-sixth that of the connecting railways. "For the longest lake routes 900 miles from Buffalo to Chicago, 1,000 from Buffalo to Duluth, the rate on grain has approximated 60 cents per ton in recent years. The return on coal has been to Chicago 50 cents, and to Duluth as low as 25 cents, or less than is paid to have it shovelled from the gutter across the sidewalk to the coal hole of the city consumer."

At present, public attention is directed to the great work of the Chicago Drainage Canal, primarily designed to discharge the sewage of the city of Chicago through the Illinois and Mississippi Rivers and furnish a large amount of water-power, but which its projectors hope will ultimately connect the lakes with the Gulf of Mexico for the purposes of navigation.

This canal, with depths of from 22 to 26 feet, has a greater area of gross section than either the Suez, Manchester or North Sea Canals.

The work is carried on under the laws of the State of Illinois, which provide for a commission to take lands, raise money and make contracts, the cost of construction being borne by the city of Chicago, under what is known as the Drainage District, and the moneys raised by taxation. The canal is now being built between Chicago and Lockport, a distance of about 34 miles; 12 or 14 miles of this work is through rock, 10 miles through clay and 10 miles through a mixture of clay, indurated earth and rock, the rock lying in the bottom.

The rock sections are 160 feet wide and about 32 feet deep. In sections where the earth overlies the rock a retaining wall is built from the rock up to the top of the bank. The entire earth sections are sloped; the width in the bottom of the earth sections running from 108 to 160 feet, and the top from 200 to 320 feet; the sides are to be rip-rapped. The top lifts of the dirt sections have been taken off generally with wagons and wheel scrapers, while the bottom lifts have been taken out with steam shovels and tram cars. The average price of the rock excavated per yard has been about 76 cents, dirt sections from 22 to 28 cents per yard. The Desplaines River also had to be diverted and strengthened for about 14 miles, and was excavated 200 feet wide and about 4 feet deep.

The fall of 1896 should see the canal to the city line completed for the 34 miles, but it will not achieve its purpose until Chicago builds lateral canals to cut off the sewage which now runs into the lake. These lateral canals will turn all the sewage into the Chicago River and from that into the canal.

The amount of rock excavation exceeds 12,000,000 cubic yards, and the total quantity of rock and earth to be moved is about 40,000,000 cubic yards; when completed the work will have cost $27,000,000.

St. Mary's Ship Canal.—A statement of the commerce through the St. Mary's Falls Canal since its opening in 1855 would be practically a *résumé* of the progress of what may be called the Lake Superior district, and an indica-

tion of the rapid development of the northern portion of the United States, and yet this would not include the great traffic which did not reach Lake Superior, for vessels from Lake Michigan and the lower lakes do not have to pass this canal.

To illustrate how progress has exceeded expectations, it is interesting to refer to a letter written by the late E. B. Ward, of Detroit (one of the most progressive men of his time), who in 1853 expressed a conviction that a lock 350 feet long and 70 feet wide would be larger than would ever be needed for the Lake Superior traffic, and stated that he considered a lock 260 feet long by 60 feet wide ample for the present century.

The two locks constructed in 1855, however, were made 350 feet by 70 feet, with a lift of 9 feet each, and passed vessels drawing 12 feet of water. In the first ten years of their existence the registered tonnage annually passing increased from 100,000 to 570,000, being augmented in the second decade to over 1,000,000 tons. The demands of lake traffic soon required a new lock, which was completed in 1881, its length being 515 feet, width 80 feet (narrowed at the portals to 60 feet), the lift was 18 feet, with a depth of 16 feet on the mitre sill. For years this lock has been totally inadequate, and during the season of navigation there has been a continued congestion of vessels both above and below, it having passed, during seven and one-half months in the year 1895, 16,793 vessels, with a total registered tonnage of over 16,000,000.

The report of the Manchester Ship Canal shows that in 1895 the tonnage passing through it was but one-tenth of that passing the St. Mary's Ship Canal. Since 1891 the traffic through the Suez Canal, in twelve months, has been below that of the St. Mary's Canal for less than eight months, the number of vessels for three years being:

	1893.	1894.	1895.
Suez Canal, 12 months	3,341	3,352	3,434
St. Mary's Ship Canal, 8 months . . .	12,008	14,491	17,956

A new lock, 800 feet long and 100 feet wide throughout, with a lift of 18 feet and a depth of 21½ feet on the mitre sill, is nearly completed, at a cost of $5,000,000, and will be opened by the United States Government to commerce in 1896, while on the opposite side of the St. Mary's River the Canadian Government have within the last few months opened for traffic a lock 900 feet long and 60 feet wide.

JOHN BIRKINBINE,
Member of the Institute, Past President Am. I. M. E., etc.,
—*The Journal of the Franklin Institute.*

GENERAL MILITARY MATTERS.

The Visibility of Colors at Great Distances.

In view of the accuracy of the long range small caliber rifles, interesting experiments were recently conducted by the Society of Civil Engineers in Paris, in order to determine the visibility of different colors. To designate the visibility of colors at great distances numbers from one to eight were taken, eight signifying invisibility. It was regarded as a matter of importance to determine how these numbers compare in clear weather, in cloudy weather and at night. The result of observation at 600 m. (650 yds.) is given as follows: In clear weather white is most distinctly visible (1), then comes Hussar blue, light blue (2), scarlet (3), green (4); gray and the color of dry

foliage are almost invisible and were marked 7. Dark blue was called 6. In cloudy weather nothing was altered in case of white, blue, green, and brown. Hussar blue becomes less visible (3), so also scarlet (4), on the other hand green becomes more visible (3). At night the results were the same as in cloudy weather, except that white becomes invisible and so passes from 1 to 8.

The colors of the German and Italian infantry (iron gray and dark blue) were classified as 6. In France, in consequence of the red képi, the dark blue coat and the scarlet trowsers,, the average number obtained was 4½. But it is believed that in reality the disadvantage of the French infantry will turn out to be less, because only that part of the red trowsers between the lower edge of the coat and the top of the bootee is visible, and even this will be so dusty after the first day's march that no actual color will be visible. The light reflected from cuirasses, helmets and sabers is not taken into account.

—*Schweizerische Militärische Blätter*, January, 1896.

BOOK NOTICES.

A Text-book on Ordnance and Gunnery, Prepared for the use of Cadets of the United States Military Academy, by Captain Lawrence L. Bruff, Ordnance Department, U. S. Army, Instructor of Ordnance and Gunnery at the U. S. Military Academy. Published by John Wiley & Sons, New York, 1896.

This text-book of nearly 640 pages has been compiled by Captain Bruff for the instruction of cadets at the Military Academy, and he has arranged it so that it can be readily used for recitation in the section room.

The work is divided into ten chapters which carry the student progressively through the course as taught at West Point, and an excellent index of forty pages has been provided.

Captain Bruff has followed in the preparation of his book the lines laid down by his predecessor at West Point, Captain Henry Metcalf, U. S. Army, retired; to whom is due the credit of appreciating how far behind the times this course was, and who labored for years to bring it out of the chaos in which he found it. He published in 1891 the book which made possible the present work.

Captain Bruff has had the cooperation of such authorities as Colonel Buffington, Captains Crozier, Smith, Birnie, Blunt and Mitcham of the Ordnance Department, U. S. Army, and of Mr. Wm. R. Quinan of the California Powder Works, which insures the excellence of what they have collaborated.

The book is well illustrated and is clearly written. Too much space is, perhaps, devoted to ordnance construction and shop work, yet as the books studied at the academy are used by the graduates for reference too much of a good thing should not be criticised, and Captain Bruff should be pleased that he has formulatad a course which although pertaining too much to the Ordnance Department for most Artillerymen, is yet in advance of any taught by his predecessors.

The first chapter is on gunpowders, and treats of its composition and manfacture, describes the instruments used in determining the specific gravity of powders; gives the various forms of powders now used in our service, and a short description of the service inspection and proof of these powders; the laws governing the combustion of powder in air and formulæ for burning in air of grains of different shapes; the velocity of emission for spherical grains and those of other shapes and the influence of the size of the grain and density of the powder upon this velocity.

Noble and Abel's experiments on the combustion of powder in closed vessels are given at length, as is also the application of these experiments to the work done by gunpowder in a gun.

About thirty pages are devoted to Sarrau's formulæ for the general equations of motion of projectiles in the bore of a gun, and to his practical formulæ for velocity and pressure in the gun. Here the work is elementary and is not up to either Glennon or Ingalls.

Noble and Abel's method and Mayevski's method for determining pressures along the bore are also given, and twenty pages are covered by a description

of the instrument used in actually determining the velocity of projectiles just after they leave the bore, and of the instruments used to find the pressure of the gases in the bore.

Chapter II. is on high explosives and smokeless powders.

It covers but thirty pages and as smokeless powders will undoubtedly be the only ones used in the future, it would seem that more space could have been devoted to this important and interesting subject. Good text-books are, however, available for those who desire to investigate this subject, and as each month brings to light some startling improvements in these new powders, no text-book could be up to date upon them.

Our future artillerymen should be taught though, more about smokeless powders and less about the old powders, which should be dropped and forgotten.

Chapter III. treats of gun steel, its physical qualities, structure and defects; gives the working qualities of steel and describes its manufacture and the treatment it receives when used for gun forgings. Thirty pages of the chapter are devoted to machines used in gun manufacture and to the pulleys, belting, wheels, &c., used in the transmission of power. The remaiaing 93 pages are given to gun construction, the elastic strength of guns, description of the breech-loaders in the U. S. service and their breech mechanisms. Wire wound guns are scarcely touched upon, although they bid fair to be the guns which should in the future be built and furnished the army.

Chapter IV. is devoted to projectiles and armor. There are good drawings of many of the projectiles, while their manufacture and use are well described. There is also given in this chapter the general discussion of the rotation of a projectile, the sectional density, how it may be varied and its effects. The various kinds of rifling used in our service are described and the means used to make the projectile take this rifling are set forth with much detail. The last ten pages of this chapter are devoted to armor and its backing and the penetration of projectiles into wrought iron and steel armor.

Chapter V. is on fuses and primers and is excellent.

Chapter VI. Gives the mathematical formulæ used in exterior ballistics.

Chapter VII. describes artillery carriages and the theory of recoil. It is a most interesting chapter and shows the work of one well versed in these subjects.

Chapter VIII. is devoted to pointing and probability of fire. The theory of pointing is well explained but the descriptions of the means used to lay our guns leaves much to be desired. The entire Ordnance Department seems to be blind to the importance of good sights, and they will not furnish them nor teach our young soldiers the importance of having the best means of laying a gun on the spot desired by the gunner. The sights furnished by the Ordnance Department to our service and described in this work are sorry affairs. The discussion of the probability of fire is exhaustive and good.

Chapter IX. describes the portable arms, sabers, straight swords, bayonets, lances and small arms; gives illustration and good descriptions of the breech mechanism of the .45 caliber Springfield rifle and the new magazine rifle. There is also a short description of the ammunition used in these small arms.

Chapter X. has 48 pages on machine and rapid fire guns, and is interesting and important.

Those who intelligently study Captain Bruff's book, will be well posted in

the elements of Ordnance Construction, and the army at large should be grateful to him for his labor in developing this Course of Ordnance and Gunnery which, although it may be improved upon by his successor, is a vast stride in the right direction.

E. St. J. G.

Handbook of Light Artillery. By A. B. Dyer, First Lieutenant, Fourth Artillery. Published by John Wiley and Sons, New York. Pp. 521.

This work is the most valuable contribution to the literature of light artillery that has appeared in our country in the last quarter century. The author designates it a mere compilation, but the credit for the selection of the material and its arrangement is still his, and he deserves great praise for both. His position as commandant of the battery at West Point, in which the Cadets of the Military Academy are instructed, as well as his services as Adjutant of the Cavalry and Light Artillery School at Fort Riley, Kansas, have enabled him to appreciate the wants of officers of light batteries, and assisted him in putting together what is of most value to them.

The subject-matter is divided into two parts. Part I. treats of mountain artillery, guns, carriages, ammunition, range tables, organization, the pack-train, the mule, supply of ammunition and care of harness, together with weights and dimensions of foreign mountain artillery. Part II. treats of field artillery,—construction and description of guns, wheels and harness; the horse and his diseases and management; the organization of artillery, its equipment and field service; transportation; machine guns; gunnery; range-finding and ranging; cordage and bridges; demolitions; books, records, tables, etc. The book is well illustrated and has an excellent index.

Officers serving in light batteries will find this hand-book indispensable in their daily duties. The material is excellent and its arrangement is so clear and simple that an index is well-nigh unnecessary. The author probably considered it necessary for completeness in include much that is in the Drill Regulations, but in our opinion that part should have been omitted, as the book will hardly be used by any one who does not possess a copy of the Drill Regulations. It also appears to us that it is high time the field artillery selected some *one* gun pit of more modern form than the four foreign ones here given, and which Colonel J. P. Sanger (now in the Inspector-General's Department) first introduced in our army, some ten or fifteen years ago.

J. P. W.

The Decline and Fall of Napoleon. By Field Marshal Viscount Wolseley, K. P. Boston, Roberts Brothers, 1895. Pp. 193.

This is the first of a series of republications in book form of some of the more important articles which have appeared in the *Pall Mall Magazine.* It is a strong and clear analysis of the causes of action, and a graphic presentation of the events in the last three years of the great commander's *active* life. Perhaps it is not too much to say that it is the broadest, the fairest, the most unbiassed view of Napoleon that any Englishman has ever given us, and coming as it does from the pen of one of England's greatest living commanders, it is entitled more than ordinary study.

The author believes that the prime factor in the decline of the great master of strategy was a peculiar disease:

"From many different sources we have irresistible evidence that upon several occasions during his later years he was subject to periodic attacks of a

mysterious malady. * * * It may, perhaps, be best defined as a sudden attack of lethargy or physical and moral prostration, sometimes accompanied by acute bodily pain." * * *

"Many careful students of this colossus among men have been compelled—unwillingly perhaps—to admit that had the Corsican general who fought at Rivoli been in command of the French army when it crossed the Sambre in 1815 our 'Iron Duke' would not have been allowed to add the 'crowning mercy' of Waterloo to the list of his glorious achievements." * * *

"It is a remarkable feature in the decline of Napoleon's fortune that he won many battles where he only just missed gaining the decisive success that would in all probability have restored his position in Europe."

This fact must have impressed every student of Napoleon. On three great occasions was this true in a marked degree, at Smolensk, at Bautzen and at Dresden.

"As far as any one now can judge of what might or what ought to have happened after the battle of Dresden, it seems very evident to me that had not Napoleon withdrawn, as he did, from the personal direction of the pursuit nothing could have saved the allied army from destruction or capitulation."

And in regard to Waterloo the author says, in this connection:

"The more I study his grandly conceived plan of campaign for 1815 the more convinced I am that the overwhelming defeat in which it ended was primarily the result of bodily disease and the failure of mental power which resulted from it at supreme moments when rapid and energetic decision was imperatively necessary for success. Had he been able to bring the mental and bodily energy of his early career to bear upon the great plan he had conceived for the destruction of Wellington and Blucher in Belgium, judging of what those commanders would have done by what they did do, I believe the cautious Englishman would at least have had to retreat in haste for the purpose of re-embarking at Ostend, whilst the fiery and impetuous Prussian would have been almost destroyed at Ligny and only too glad to place the Rhine between the remnants of his beaten army and the victor of Jena. * *

"Nor can I otherwise explain to myself how two armies situated as were those of Wellington and Blucher on June 14th, 15th and 16th were allowed to escape during the two following days from the destruction with which Napoleon's most ably devised scheme of operations ought to have overwhelmed them."

General Wolseley's estimate of Napoleon's character is remarkably just and true. This military critic is certainly not sparing in his terms of praise, nor is he blinded to the faults of the great military genius:

"Even those who hate his memory will admit that his brain was almost superhuman in its grasp of subjects that interested him. * * * To men of action prone to worship the great history-makers of the world, he is the most remarkable and the greatest human being who has ever walked this earth. * * * It is dangerous, indeed presumptuous, for any soldier to criticise Napoleon's military conceptions and plans. * * * Napoleon's character is a puzzle to most men and the composition of his brain is difficult to analyse. He had no real appreciation of what was beautiful in nature, felt little of the true poetry of life, and cared nothing for what we regard as virtue; but all we know of what he said or wrote regarding history in which he had no part, or about those who made it, or regarding the service of govern-

ment, and the institutions and general machinery which keep civilized states going, displays wisdom and liberality. * * * Had he loved his own personal renown less and France more how different would have been his end! * * * He knew how to win the imagination of Frenchmen and how with French armies to conquer; but he did not know how to die a hero's death. * * * Why did he not die with those who died for him upon that most eventful day of his life? But as a patriot how little worthy was he of all the reverence and devoted love bestowed upon him by his brave, faithful and loyal army! It is as natural to die as to be born and it can matter little whether you fall like a soldier on the field of battle when young and vigorous, or 'sicken years away' to die on your bed.

In his account of the campaign of Waterloo we find such fair opinions expressed as leave no doubt as to the careful study he has given the subject and the correct views he has arrived at. He gives the Prussians due credit for the important part they played. He thinks Grouchy was unjustly blamed for his conduct, but at the same time he admits that had he been a greater soldier than he was he would have marched by the bridges over the Lasnes.

Altogether this little work is in its small compass a masterpiece on the much discussed subject of Napoleon's decline and fall. It is written with a sincerity of purpose and a strength of conviction which are very refreshing, and the tone of the book rises to the height we have a right to expect from so great a representative of the army that has furnished history with deeds of gallant daring, among the finest it has to record.

J. P. W.

The Rise of Wellington. By General Lord Roberts, V. C., Boston, Roberts Brothers, 1895. Pp. 198. With Portraits and Plans.

This is the second of the series of republications in book form of some of the more important articles which have appeared in the pages of the *Pall Mall Magazine*, and forms an interesting companion volume for the first, Viscount Wolseley's "Decline and Fall of Napoleon."

Wellington's early life and career, particularly his service in India, was an excellent preparation for his successes in Spain and in the Netherlands.

He was educated at a private school, then at Eton and finally at a military school at Angers, and entered the army as an ensign at the age of seventeen. His powerful family influence enabled him to reach the grade of colonel in ten years. In 1794 he served in Belgium and Northern Germany. In 1797 his regiment went to India, and the account of his excellent services there is extremely interesting, illustrating his peculiarities of character as well as his military ability. He had command of several important expeditions and invariably accomplished his task satisfactorily, he was governor of Mysore for several years, and there proved his ability in civil and military administration, in 1802, at the age of thirty-three, partly on account of his own merits but also through the influence of his brother, Governor-General of India, he became a Major-General. In spite of the exceptional favor with which he was treated he took full advantage of every opportunity thrown in his way, and proved himself equal to his high and responsible duties. He was invariably much liked by the officers under his command.

His experience in diplomacy as well as in war was of immense value to him afterwards in commanding the Portuguese and Spanish troops in the Peninsula, and later the mixed forces in the Netherlands, with so little friction. He suggested the policy of encouraging the native states to keep up armies

capable of taking the field and assisting in the defence of the country, the contingents from which now add so materially to England's military strength there.

Wellington was an ambitious man, with a high opinion of his own qualifications. When he was appointed Commandant of Seringapatam in supersession of Major-General Baird he does not seem to have realized that the latter had been badly treated, but when it was proposed to associate with him a civil commissioner in Mysore, he refused point blank to divide his authority with any one. After all his rapid promotion he complained that he had never received anything but injury.

The Peninsular period is described with considerable fairness, but the campaign in the Netherlands is filled with the old English prejudices. Wellington's view that Napoleon should have attacked his right is upheld, as well as his disposition of the troops before the campaign opened, whereas no military writer of note to-day holds these views. In this connection it is interesting to read Wolseley's opinion. Finally, the Prussians receive little credit for their part in the battle of Waterloo, although they saved the day.

"The place I should be inclined to assign to Wellington as a general would be one in the very first rank—equal, if not superior, to that given to Napoleon," General Roberts says; and again: "In the Waterloo campaign, while Napoleon made many mistakes, Wellington made none." These statements belong to the first quarter of this century, not to the last.

While in command in the field he was continually complaining about the defects in the military system, but in all the after years when he was both Cabinet Minister and Commander-in-Chief he did little to remedy these defects. He was strongly in favor of long service and old soldiers and believed that the efficiency of an army depended as much upon the thorough training and soldierly habits of the men as upon the ability of the officers. In almost all his other views, such as his objection to the formation of an army reserve and the special education of staff officers he was mistaken, and his views have not been followed.

Read in connection with the fall of Napoleon this account of the rise of Wellington has a peculiar interest, but the principal charm of this work is in the development of the military and personal character of this great English soldier in the Indian Period, and in the description of that period the author shows his ability to grasp the main features and bring them out with graphic power, due, no doubt, in part at least, to his familiarity with all that pertains to India.

The entire book is well written and gives a very clear idea of the life, character and deeds of Wellington. It is to be regretted that the last chapter should indicate a lack of careful study of the latest literature on the subject (of which Ropes' work is the type), the main features of which have been so generally accepted, even by English military critics.

J. P. W.

Experiences of a Prussian Officer in the Russian Service During the Turkish War of 1877-78. By Richard Graf von Pfeil, Major and Battalion-Commander in the Grenadier Regiment No. 11. Translated from the German by Colonel C. W. Bowdler. London: Edward Stanford, 1893. Pp. 362, With Map.

The author of this interesting account of experiences in the Russian army

during the last great war between Russia and Turkey was an officer of good standing in the German army, who had attained the rank of Captain, and had been trained in the field during the campaigns of 1866 and 1870-71. He was therefore capable of passing judgment on the conduct of the military operations. He took service in the Russian army at the outbreak of the war, and proved his abilities by the duties confided to him, as well as by the fact that he was transferred to the Guard Corps.

The narrative was compiled from his letters written to friends during the campaign, and also from his carefully kept diary. His criticisms give the impression, at the beginning, of strong prejudices, but this soon passes away and gives place to a feeling of confidence in his judgment and sincerity.

Captain von Pfeil joined the Russian army in the Balkans in October, 1877, and had his first service in the Hanikiöi Valley, on outpost duty. In January, 1878, he took part in the passage of the Balkans, being attached to the staff of Prince Mirski, to whom he appears to have been very useful:

"When I saw how Prince Mirski, who was no longer young, and had only recently recovered from sickness, bore the hardships of the march, I was really ashamed of my own secret discontent. But now, in the icy cold and deep snow, when he heard the news that he could get no accommodation, his self-control completely broke down. He was quite beside himself when he saw that not one of his staff was near him * * *; he complained loudly that the troops had to suffer so much, and declared that he would just throw himself upon the snow and let everything take its chance. * * * I at once took everything that was necessary out of my traveling bag * * *, and requested the Prince to write the necessary reports to Radetski, and the orders for the troops, the purport of which I discussed with him. * * * Having settled this, I represented to the Prince that at his age, and in face of his still uncured illness, it was simply impossible for him to remain in the open. He contradicted me, and was even annoyed, but this was quite immaterial to me. I got hold of the Cossack who knew the way to Seltis; I made him ride in front, and followed him with my lantern at my back, fastened to the belt of my great coat, so that it cast a light on the road behind me; two Cossacks supported the Prince, who never ceased to grumble, under the arms, and so we started on our journey. The road was certainly frightful; it led down a mountain side and was covered with ice. We fell down constantly, one after the other, but the prospect of perhaps getting into a warm room made the Prince happier by degrees, and he continued to thank me heart and soul."

The battle of Shipka is described from the point of view of Mirski's column, and therefore some new pictures are presented, as Skobelef's advance is the one usually described. A few extracts will serve to illustrate the character of the work and at the same time furnish glimpses of the stirring scenes enacting.

"It was quite a common occurrence for the relief to find a sentry frozen on his post, as is so marvellously depicted in one of Vereshchagin's works; the relieving sentry took the place of the dead man in the expectation of being found there in a few hours as stark and stiff as his predecessor." ——

"The situation looked very bad. Our exhausted troops beat back attack after attack with a heroism which I cannot sufficiently praise, and especially the Rifles under brave Colonel Krock highly distinguished themselves. But there is an end to everything, and we saw that the Turks were making

progress, though only slowly at first. I was convinced that at any moment we might have to beat a full retreat.

"Suddenly on our extreme left such a thundering hurrah was heard that Prince Mirski at once hurried off in that direction. He was met by Colonel Krock's aid-de-camp galloping, shouting hurrah, and waving a piece of paper in his right hand. This he handed to the Prince. It was a piece of white paper covered with grease-spots, which probably had been used to roll meat up in, but it is now an important leaf in the history of the war, for it contained the following words, few but of immense importance: "Hurrah, Skobelev is advancing with bands playing, Krock."

"It was a moment which one must have lived through to understand. Wellington must have felt the same at Waterloo when Blücher arrived."——

"The appearance of one old Turkish soldier with a long grey beard will live in my mind forever. He sat upon a stone, his back propped up against a wall. His uniform was undone and showed his hairy chest, from which blood was slowly welling. On his knees lay the Koran, and his lips moved in prayer. As I passed he raised his eyes to me, and I could see that he was in full possession of his senses."——

"At last I found Skobelev, who was surrounded by a large number of people, among them many foreigners, principally English newspaper correspondents, and the painter Vereshchagin, afterwards so renowned for his pictures of the war. Skobelev sat on his historical white horse and appeared to be in the act of giving some orders. He was then just thirty-three years old and of a handsome appearance, reminding one rather of the Emperor Frederick in his younger years, and his face, framed in its fair whiskers and beard, beamed with joy and triumph. * * *

"I had the good luck to take part in that ride which Vereshchagin has immortalized in one of his best pictures. Seldom have I seen such enthusiasm as Skobelev's troops showed for their leader. Caps were thrown up in the air, the hurrahs were deafening, and many men pressed round the General's horse. * * * On the way to where Prince Mirski was he tried to explain to me the reasons for his late arrival. * * * It is now well known, as we indeed had never for a moment doubted, that he had delayed intentionally, on mean grounds of personal interest, in the hope that Prince Mirski would be beaten, and that he, Skobelev, would on the following day wipe out the defeat and appear as the hero of the battle."

The narrative then takes us to Kazanlik, Adrianople, San Stefano and Constantinople, with characteristic remarks on the Grand-Duke Nicholas, General von Totleben, Count Ignatier and other prominent people.

These reminiscences are chiefly valuable for the insight they give into the social conditions obtaining in the Russian army, the light they throw on the character and conduct of the officers and men in their military duties, and the pictures they give of prominent personages and stirring events on the battle-field and in camp.

The general scope of the work is given in its title, the interest is well sustained, although the quality of the material is somewhat unequal, many pages being without any interest to the general reader; its *personal* character gives it a charm which is wanting in any simple record of the events. The map covers but a small portion of the field of operations, and is consequently unsatisfactory.

The translation, in general, is excellent, but there are a few sentences that retain marks of their German origin.

J. P. W.

Abriss der Taktik. Reinhold Günter, Oberlieutenant in Füsilierbataillon No. 17 (Fribourg). Albert Müller's Verlag, Zürich, 1895. 2 Francs. Pp. 133.

This little work is intended as a repertory, for the convenience of the young officer, the non-commissioned officer and the private soldier of the Swiss army. It is a brief summary of the principles of tactics based on the regulations, and it is remarkable how much the author has condensed into this small space. It constitutes an excellent hand-book of reference for the student of the subject who desires to take a rapid survey of the field and fix in his mind the principles he has already learned.

The book concludes with a short but interesting essay on the history of tactics.

There are a few statements in the text which are hardly in accord with the best opinions of to-day, viz:

"Since 1870 it has been an accepted fact that cavalry is too costly an arm to be sacrificed in battle." Again, he says that "The defender will make use of the bayonet when the enemy's advance is slow or when he is short of ammunition," as if those were the only occasions. Finally, he makes the statement: "If the Austrians in 1866 neglected to prepare sufficiently for the assault by a proper infantry fire, the Prussians now (1870) failed to concentrate their artillery in adequate masses for this same purpose," when in reality their use of artillery in this way has been considered typical and has furnished the model of future tactics.

J. P. W.

Historischer Rückblick auf die Verpflegung der Armeen im Felde. I Lieferung. Oberstlieutenant Otto Meixner, des Generalstabs-Corps, Lehrer an den Administrativen Militär-Fachcursen. L. W. Seidel & Sohn, Wien, 1895. Pp. 201. 2 Maps.

The literature relating to the *supply of armies in the field* is extremely meager, consequently a work on this subject by one who teaches it at the military schools in Vienna will be sure to be well received. Those who became great masters of the art (like the officers of our Quartermaster's and Commissary Departments during the war) have received little recognition of their services, because the credit of everything relating to the army goes to him who wins the battles. Nevertheless it is a subject of immense importance, well worthy of careful study, particularly as the rapidity with which the events of future wars will succeed one another will not give time to learn it in the field.

The work before us is Part I. of the general work and treats the subject historically, the first section covering the time from the first appearance of standing armies to the French Revolution, the second section from the French Revolution to and including the Napoleonic Wars (1789-1812), the third section (to constitute Part II. of the work) from the Napoleonic Wars to the present time.

The history of the first period shows us how the question of supply developed into a branch of the command of armies, and how the system of supply by means of large magazines and store-houses became general. The armies formed immense bodies, only rarely subdivided, and then only into center,

and right and left wing, or into lines, for their supply. For this reason, and because of the lack of mobile field supply stations, the armies of those days were so unwieldy and slow. The supply train was tied to a *line*, so that its usefulness was entirely limited to what is now called the *étappe* service.

In the second period we find the essentially *negative* use which had been made of the supply by magazines developed in the first period, converted by Napoleon into a *positive* use of great value. He brought out the great advantage of *living on the country*. His earlier campaigns iu the rich valleys of Italy and southern Germany permitted this; but even as early as 1806 and 1807, in more northern and less favored countries, his armies began to feel the want of more certain sources of supply, and marauders were abundant; and in Russia in 1812 the evils of this method of supply reached a climax.

In the course of the work the author gives interesting details of the supply of the armies of Napoleon in Italy and Arch-Duke Charles in Germany in 1796, and of the armies of Napoleon in the campaigns of 1805, 1806, 1809 and 1812. More than half the entire work (Part I.) is devoted to the last-named campaign, so it is the basis of the modern system.

Lieutenant-Colonel Meixner has accomplished his task with marked ability, and has given us a valuable work on this most important branch of the art of war. When completed this work will be almost unique in the literature of the subject of supply of armies. It is remarkable for clearness and conciseness of expression, and the subject-matter is well arranged and presented in an interesting form.

J. P. W.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6 *d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6 *d.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7 *s.*

United Service Gazette. [*U. S. Gazette.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C. Per year* £1 10 *s* 6 *d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*
17 *Great George Street, London, S. W. Per year* 2 *s.*

Army and Navy Gazette. [*A. and N. Gazette*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12 *s* 6 *d.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Journal of the United Service Institution of India. [*Jour. R. U. S. I. India*] *Monthly.*
Simla, India. Per year $2.50.

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6*d each.*

Electrical Review, [*Elec. Rev.*] *Weekly.*
22 *Paternoster Row, London. Per year* $6.00.

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris. Per year* 18 *Fr.*

Revue du Cercle Militaire. [*Cercle*] *Weekly.*
37 *Rue de Bellechasse, Paris. Per year* 27 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht*] *Weekly.*
55 *Rue de Chateaudun, Paris. Per year* 30 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
23 *Rue Madame, Paris. Per year* 30 *Fr.*

Revue Maritime et Coloniale. [*R. Maritime*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 56 *Fr.*

Revue d'Artillerie. [*R. Artillerie*] *Monthly.*
5 *Rue des Beaux-Arts, Paris. Per year* 22 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris. Per year* 27 *Fr.*

Revue Militaire de l'Etranger. [*Etranger*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 15 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
8 *Rue St. Dominique, Paris. Per year* 45 *Fr.*

Journal des Sciences Militaires. [*Sciences Militaires*] *Monthly.*
Rue et Passage Dauphine 30, *Paris. Per year* 40 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils. [*Ingénieurs Civils*] *Monthly.*
10 *Cité Rougemont, Paris. Per year* 36 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris. Per year* 33 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustius, 55, *Paris. Per year* 12 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
76 *Rue de Seine, Paris. Per year* 6 *Fr.*

GERMANY.

Militaer-Wochenblatt. [*Wochenblatt.*] *Fortnightly.*
Koch Strasse, 68, *Berlin, S. W.* 12. *Per Year* 20 *M.*

Archiv fuer die Artillerie-und Ingenieur Offiziere. [*Archiv.*] *Monthly.*
Koch Strasse, 68-78, *Berlin, S. W.* 12. *Per year* 12 *M.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin, W.* 8. *Per year* 32 *M.*

Marine Rundschau. [*Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W., Berlin.*

Deutsche Heeres Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

Kriegswaffen. [*Kriegswaffen.*] *Monthly.*
Rathenow, Germany. Per year $4.50.

Militarisches. [*Militärisches.*] *Monthly.*
Zuckschwerdt & Co., Leipzig. Per quarter 4.75 *M.*

AUSTRIA.

Mittheilungen ueber Gegenstaende des Artillerie und Genie-Wesens. [*Mitth. Art. u. G.*] *Monthly.*
Wien, VI, Getreidemarkt 9. *Per year* 1 *Fl.* 50 *Kr.*

Mittheilungen aus dem Gebiete des Seewesens. [*Seewesens.*] *Monthly.*
Pola. Per year 12 *M.*

Organ der Militaer Wissenchaftlichen Vereine. [*Vereine.*]
Wien I, Stauchgasse No. 4. *Per year,* 8-14 *numbers,* 6 *Fl.*

Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines. [*Z. Architekten Vereines.*] *Weekly.*
I. Eschenbachgasse, No. 9, *Wien. Per year* 10 *Fl.*

SWITZERLAND AND BELGIUM.

Schweizerische Zeitschrift fuer Artillerie und Genie. [*S. Zeitschrift.*] *Monthly.*
Frauenfeld, Switzerland. Per year 8 *Fr.* 20 *centimes.*

Monatschrift fuer Offiziere Aller Waffen. [*Monatschr.*] *Monthly.*
Frauenfeld, Switzerland. Per year 5 *Fr., plus postage.*

Allgemeine Schweizerische Militaer-Zeitung. [*A.S.M. Zeitung.*] *Weekly.*
Basel, Switzerland. Per year, 8 *Fr.*

Revue Militaire Suisse. [*R. M. Suisse.*] *Monthly.*
Escalier-du-Marché, Lausanne, Switzerland. Per year 10 *Fr.*

Revue de l'Armée Belge. [*A. Belge.*] *Bi-monthly.*
22 *Rue des Guillemins, Liège, Belgium. Per year* 13 *Fr.*

La Belgique Militaire. [*Belgique M.*] *Weekly.*
Rue St. Georges 32, *Ixelles, Belgium. Per year* 12.50 *Fr.*

SPAIN, PORTUGAL AND SOUTH AMERICA.

Memorial de Artilleria. [*M. de Art.*] *Monthly.*
Farmacia, num. 13, *Madrid, Spain. Per year, U. S.,* $3.40.

Revista General de Marina, [*R. G. de Marina.*] *Monthly.*
56 *Calle de Alcalá, Madrid, Spain. Price U. S.* $4.45.

Revista Cientifico-Militar. [*Cientifico M.*] *Semi-monthly.*
5 *Calle de Cervantes, Barcelona, Spain. Per year* 32 *Fr.*

Revista do Exercito e da Armada. [*Exercito.*] *Monthly.*
Largo de S. Domingos No. 11, *Lisbon, Portugal. Per year U. S.* $6.00

Revista Militar. [*R. Mil. Portugal.*] *Semi-weekly.*
262 *Rua da Princeza, Lisbon, Portugal. Per year,* $2.60.

Revista Militar. [*R. Mil. Chile.*] *Monthly.*
Santiago, Chili.

Revista Maritima Brazileira. [*R.M. Brazil.*] *Bi-monthly.*
Rue do Conseheiro Saraiva n. 12, *Rio de Janeiro, Brazil. Per year* $10.00.

Revista da Commissao Technica Militar Consultiva. [*R. da Commissao.*] *Bi-monthly. Praça da Republica N.* 32, *Rio de Janeiro, Brazil.*

Circulo Naval,—Revista de Marina. [*R. de Marina.*] *Monthly.*
Casilla num. 852, *Valparaiso, Chili.*

Boletin del Centro Naval. [*Boletin.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00

El Porvenir Militar. [*Porvenir.*] *Weekly.*
258 *Calle Montevideo, Buenos Aires, Argentina.*

HOLLAND AND SCANDINAVIA.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland. Per year, U. S., $2.00.

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militeert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Stockholm, Sweden. Per year, U. S., $1.75.

ITALY.

Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

Rivista Marittima. [*R. Maritt.*] *Monthly.*
Rome. Per year 25 *L.*

UNITED STATES.

The Engineering News. [*Eng. News.*] *Weekly.*
Tribune Building, New York City. Per year $5.00.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* $3.00.

The Iron Age. [*Iron Age.*] *Weekly.*
96-102 *Reade Street, New York City. Per year* $4.50.

Journal of the Military Service Institution. *Bi-monthly.*
Governor's Island, New York City. Per year $4.00.

American Engineer and Railroad Journal. [*Eng. and Rail. Jour.*] *Monthly.*
47 *Cedar Street, New York City. Per year* $3.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

Electric Power. [*Elec. Power.*] *Monthly.*
27 *Thames Street, New York City. Per year* $2.00.

Digest of Physical Tests. [*Digest.*] *Monthly.*
1424 *N. 9th Street, Philadelphia. Per year* $1.00.

The Engineer. [*Eng. N. Y.*] *Fortnightly.*
106-108 *Fulton Street, New York City. Per year* $2.50.

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
World Building, New York City. Per year $3.00.

Journal of the American Chemical Society. [*J. Chem. S.*] *Monthly.*
Easton, Pa. Per year $5.00.

Journal of the Franklin Institute. [*Frank. Inst.*]
Per year $5.00.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] *Bi-monthly.*
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Pennsylvania Magazine of History and Biography. [*P. Mag. of Hist.*] *Quarterly.*
13 *Locust Street, Philadelphia. Per year* $3.00.

Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. Per year $3.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the U. S. Naval Institute. *Quarterly.*
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. Per year $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. Per year $3.00.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City. Per year* $3.00.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City. Per year* $2.50.

The United Service. [*U. Serv.*] *Monthly.*
1510 *Chestnut Street, Philadelphia. Per year* $2.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] *Quarterly.*
Navy Department, Washington, D. C.

Military Information Division. [*Mil. Inf. Div.*]
War Department, Washington, D. C.

ORGANIZATION AND ADMINISTRATION.

Imperial defense.—**A. and N. Gazette,** Sptember 5.

The necessity for an army as well as a navy for the maintenance of the Empire.—**Jour. R. U. S. I.,** June, 1896.

An item in the defense of our Eastern Empire.—**U. S. Gazette,** August 22.

Source of England's power.—**U. S. Gazette,** August 22.

The need of increasing the personnel of our fleet, England.—**U. S. Gazette,** July 25.

Volunteer naval defense.—**U. S. Gazette,** July 11.

The defense of Indo-China.—**Marine F.,** August 10.

The English channel squadron.—**Marine F.,** August 10.

Our food supply in time of war, England.—**U. S. Gazette,** July 25.

Papers on the functions of the army and navy in the maintenance of the British Empire, and on the invasion of England.—**Mil. Inf. Div.,** No. 9.

The defense of Canada, and the Indian question in Canada.—**Mil. Inf. Div.,** No. 9.

The United States coast defenses.—**Rev. of Rev.,** September.

Coast defenses and the artillery.—**A. and N. R.,** August 29.

War contributions and military requisitions.—**R. Infanterie**, July 15.

Relative strength of navies.—**Iron Age**, July 16.

War and the economists.—**Cercle**, July 18, August 1, 8, 15, 22.

Re-enlistments and guaranties of employment for non-commissioned officers, and ex-soldiers in European armies.—**Mil. Inf. Div.**, No. 9.

TACTICS, STRATEGY AND MILITARY HISTORY.

The tactics of assault.—**Avenir**, July 14, 31.

Notes on formations for combats in foreign infantries, Russia.—**R. Artillerie**, July, August.

Small caliber bullets, and battle formations.—**Avenir**, August 25.

German, French and Russian systems of attack.—**U. S. Gazette**, July 18.

Tendencies of the German infantry at the present day.—**Cientifico M.**, June.

Present tendencies in the German infantry.—**Etranger**, June.

The initiative and unity of doctrine in the German army.—**Etranger**, July.

The future infantry weapon.—**Mitth. Art. und G.**, November 5 and 6.

Forced marches.—**Avenir**, September 1.

Two studies on the marching of infantry.—**R. Infanterie**, August 15.

The prelude to the battle.—**A. M. Zeitung**, June 1.

The battle in the next war.—**Heeres-Zeit.**, August 19.

The cannon and the small arm in modern tactics.—**Avenir**, June 26.

Smokeless powder: its influence on tactics.—**Mil. Inf. Div.**, No. 9.

Small-arms and cannon.—**Avenir**, July 21, 28.

Rapid-fire guns or high-power guns.—**Avenir**, August 28.

Remarks on General Rohne's regulation of fire of infantry and field artillery in battle.—**Wochenblatt**, August 1.

The umpire on the zone of action of field artillery.—**Wochenblatt**, August 19.

The artillery in battle.—**Heeres-Zeit.**, September 2.

The attack and defense of coasts.—**R. Artig.**, July.

Coast defense.—**Yacht**, July 25.

The defense of coasts (Brialmont).—**Génie M.**, June.

The artillery fighting power of ships.—**Seewesens**, No. 8.

French considerations on the placing and employment of artillery on armored ships (Nicol).—**Rundschau**, September.

Sea-coast artillery and torpedo defense.—**Mitth. Art. und G.**, No. 7.

The heavy artillery of the future, with special reference to its service.—**Jour. M. S. I.**, September.

Cavalry against cavalry.—**Heeres-Zeit.**, July 29.

U. S. cavalry.—**A. and N. Journal**, September 5.

A raid into Siberia (with sketch).—**R. Cavalrie**, June.

Armored ships in battle.—**Rundschau**, July.

The value of torpedo boats in war.—**Seewesens**, No. 8.

Facts about "inner" and "outer" lines of strategy.—**Heeres-Zeit.**, August 29, September 2.

Tactical and strategical principles of the present day.—**Beiheft**, No. 4.

Attack of fortifications; Rocchi.—**A. Belge**, May, June.

Notes on mountain warfare.—**Jour. R. U. S. I., India**, July.

Cover, screen, and illusion.—**Jour. R. U. S. I., India**, July.

The new Indian war.—**A. and N. Journal**, August 22.

Dogs in modern war.—**A. and N. Register**, September 5.

War dogs.—**U. S. Gazette**, August 29.

The Soudan expedition.—**A. and N. Gazette**, August 8.

The Matabele rising.—**A. and N. Gazette**, August 15.

The British in Zanzibar.—**Pub. Opin.**, September 3.

The bombardment of Zanibar.—**A. and N. Gazette**, August 29.

To Kumassi and back with the Ashanti expeditionary force, 1895-1896.—**Jour. R. U. S. I.**, August.

Campaigns of the English in Egypt and the Soudan.—**R. Infanterie**, July 15, August 15.

The British expedition against the Ashantis, (with map).—**Etranger**, July, 1896.

The Egyptian expedition in the Soudan (two maps).—**Etranger**, August, 1896.

The Jameson raid as a military operation.—**A. and N. Journal**, September 12.

British responsibility for Turkey. —**Pub. Opin.**, September 3.

The progress of Australian federation.—**Rev. of Rev.**, August.

Russia and England in Persia.—**Pub. Opin.**, August 13.

Great Britain surrenders Trinidad to Brazil.—**Pub. Opin.**, August 13.

Venezuela's reply to the British Blue-Book.—**Pub. Opin.**, July 30.

International arbitration.—**A. and N. Gazette**, September 5.

Lord Chief-Justice Russell on international arbitration.—**Rev. of Rev.**, September.

The Samoan protectorate a failure.—**Pub. Opin.**, August 27.

The British expedition against Chitral, 1895.—**Monatschr**, June, July, August.

Military notes on the campaign in Cuba.—**M. de Art.**, June, July, 1896.

The failure of the Spanish army in Cuba.—**Pub. Opin.**, August 6.

The new disposition of Italian troops in Erytrea.—**A. and N. Gazette**, August 15.

The Italians in Africa.—**Etranger**, June.

Report of General Lamberti on the battle of Adowa.—**Avenir**, August 11, 21, 25.

The battle of Adowa.—**Cercle**, July 25, August 1, 8, 15.

Before and after Adowa.—**Jahrbücher**, August.

Critical study of the war between Italy and Abyssinia.—**R. Infanterie**, July 15, August 15.

The Italian war in Africa, and the Triple Alliance.—**Monatschr**, June.

The situation in Madagascar.—**Avenir**, June 30.

The Franco-Brazilian dispute.—**Marine F.**, July 10.

Affairs in China.—**Engineering**, August 14.

End of the insurrection in Formosa.—**Pub. Opin.**, August 20.

Settlement of the Cretan question.—**Pub. Opin.**, September 3.

Military history of the zone of action of the redoubts of Antwerp.—**A. Belge**, July, August.

Marshal Dode de la Brunerie, (1812).—**Heeres-Zeit.**, August 29.

Radetzky in the autumn campaign of 1813.—**Jahrbücher**, July.

The campaign of Soult in Portugal.—**Exercito**, June, July.

Could Marshal Bazaine have saved France in 1870?—**R. Univ.**, September.

The decisive day of Orléans in the autumn of 1870.—**Wochenblatt**, July 11.

The battle of the Mans, January, 1871.—**Beiheft**, No. 5.

The battle of St. Privat, August 18, 1870.—**A. Belge**, July-August.

History of the French infantry.—**R. Infanterie**, July 15, August 15.

Gribeauval, the first Inspector-General of French artillery, in Austria.—**Vereine**, Vol. LIII, No. 1.

The campaign of the Bavarians against Denmark, 1849.—**A. M. Zeitung**, July 13, 16.

The operations of the Russian General Rüdiger in 1831.—**Vereine**, Vol. LIII, No. 1.

The frontier forts of Pennsylvania.—**P. Mag. of Hist.**, July.

Military hospitals at Bethlehem and Lititz during the American Revolution.—**P. Mag. of Hist.**, July.

Our cavalry in Mexico.—**U. Serv.**, August, September.

Answer to "The First Six Weeks' of McClellan's Peninsula Campaign."—**U. Serv.**, August.

The campaign and battle of Chickamauga.—**U. Serv.**, September.

The U. S. and England.—**Yacht**, July 11.

Relations between politics and war.—**Cientifico M.**, June.

General von der Goltz—Pascha.—**A. S. M. Zeitung**, May 28.

Moltke's projects for the campaign of 1866 against Austria.—**Jour. R. U. S. I.**, July.

The operations of the Buluwayo field force in March and April, 1896.—**Jour. R. U. S. I.**, July.

Li Hung Chang in Europe.—**Heeres-Zeit.**, July 1.

The Chino-Japanese war.—**Proceedings R. A. I.**, August.

Mind and matter in war.—**Heeres-Zeit.**, August 15, 22.

Moral influences in war.—**Jour. R. U. S. I., India**, July.

Studies on war.—**Wochenblatt**, September 5.

The wars of Frederick the Great, review.—**Wochenblatt**, August 19.

Greatness of generals.—**Wochenblatt**, August 6, 8.

DRILL REGULATIONS AND MANEUVERS.

The Aldershot maneuvers.—**A. and N. Gazette**, September 5.

The framing of orders in the field.—**Jour. R. U. S. I.**, July.

Naval maneuvers, England.—**U. S. Gazette**, August 1, 8.

The English naval maneuvers.—**Yacht**, July 25, August 8.

Military maneuvers.—**U. S. Gazette**, August 29.

The army maneuvers.—**U. S. Gazette**, September 5.

Artillery in the army maneuvers.—**Avenir**, July 7.

The theatre for the maneuvers, France, 1896.—**Avenir**, August 21.

French grand maneuvers.—**R. Cavalrie**, June, July.

Hospital service in the field.—**Cercle**, August 29.

Program of maneuvers of the 12th and 17th Army Corps.—**Cercle**, September 5.

Firing regulations for the French field artillery.—**Mitth. Art. und G.**, Nos. 5 and 6.

Program of naval maneuvers for 1896, France.—**Avenir**, July 3.

The naval maneuvers in the Mediterranean.—**Yacht**, July 25, August 1.

Maneuvers of the III. Army Corps, Swiss (with map).—**R. M. Suisse**, August, with supplement.

The umpire at the maneuvers.—**A. S. M. Zeitung**, September 5.

An Austrian patrol in the maneuvers of 1895.—**Wochenblatt**, July 1.

The new regulations for the Russian cavalry.—**Wochenblatt**, July 11

The new drill regulations of the Russian cavalry.—**Cercle**, July 25

Russian firing regulations, 1896.—**Jahrbücher**, August.

New Russian regulations for maneuvers and fire of a group of batteries.—**R. Artig.**, June, 1896.

March of the Russian troops, 1895.—**Etranger**, June.

Firing regulations of the German field artillery (1893) with recent modifications.—**R. Artillerie**, July.

Regulations for the training, treatment, and employment of war dogs by the rifle-battalions of the German army.—**Mil. Inf. Div.**, No. 9.

What we are to expect and what not expect from drill regulations.—**Heeres-Zeit.**, June 27.

The initiative and the regulations.—**Cercle**, July 4, 11, 18.

Extended order drill regulations, U. S.—**A. and N. Register**, July 11.

The Waldersee method of training infantry for field duty.—**Wochenblatt**, July 18, 22.

Instruction of our under-officers, Germany.—**Wochenblatt**, August 12.

Instruction and training of a light battery in view of the altered conditions due to the introduction of the two years' service.—**Archiv**, July-August.

The necessity for proper field-artillery practice-grounds, and their equipment.—**Jour. M. S. I.**, September.

Physical training in the Army.—**U. S. Gazette**, September 5.

Swimming.—**Avenir**, August 21.

On the question of the instruction and training of infantry, and considerations on the new regulation for firing practice.—**Heeres-Zeit.**, August 8.

Firing instruction and training and the fire of infantry in battle.—**Monatschr**, July.

The training and instruction of infantry by its leaders.—**Monatschr**, August.

ARTILLERY MATERIAL.

Long guns.—**Eng.**, August 14.

Light rapid-fire guns.—**Avenir**, August 4.

Material of the German field artillery (illustrated).—**R. Artillerie**, July.

A new material for the Swiss artillery.—**Etranger**, August.

The French 120 mm. field howitzer, (with plates).—**Jour. R. U. S. I.**, June.

Projectile and caliber of a new field gun.—**Wochenblatt**, August 26, 29.

The future field artillery and rapid-fire cannon.—**Vereine**, Vol. LII., No. 6.

The great Krupp works.—**Scien. Amer.**, Aug. 22.

The Ruelle navy gun factory.—**Marine F.**, June 25.

The Imperial Ottoman arsenal.—**A. and N. Gazette**, July 4.

Steel for guns (illustrated).—**Boletin**, April, May.

Mountain gun of 7.5 cm., rapid-fire, Krupp system, (adopted for Cuba).—**M. de Art.**, June.

Bids on and award of contracts for army gun-carriages, gun forgings, mortars, etc.,—**Amer. Mach.**, August 13.

The new German howitzer for foot artillery.—**A. S. M. Zeitung**, May 28.

The field artillery of the future.—**A. Belge**, May-June.

Rapid-fire caponiére gun, Nordenfeldt-Cockerill.—**A. Belge**, May-June.

Fortification carriage for 57 mm. rapid-fire gun.—**A. Belge**, May-June.

The automatic mitrailleuse, m. 1896, Nordenfelt.—**A. Belge**, July-August.

Field material of the 75 mm. rapid-fire gun, Darmancier system.—**A. Belge**, July-August.

Rapid-fire guns in Germany.—**Monatschr**, July 11.

Recent progress in naval artillery and armor.—**Yacht**, July 4.

Formulas for armor piercing.—**Eng.**, July 24.
American plate trials.—**Eng.**, August 7.
The French melinité projectile.—**Seewesens**, No. 9.
Explosive projectiles.—**Marine F.**, July 25.
History of explosives.—**A. Belge**, July-August.
Gun-cotton in France.—**Boletin**, May.
Large explosions, and their radii of danger.—**Engineering**, August 29, September 4.
The development of smokeless powder.—**J. Chem. S.**, August.
Smokeless powder specifications.—**A. and N. Journal**, August 29.
Griffith on the testing of smokeless powders, (Professor Smith's chronograph used).—**Arms and Explosives**, July 1.
Dupont's smokeless in rifles.—**Shooting and Fishing**, July 30.
Nitro-powders in rifles.—**Shooting and Fishing**, August 27.
An improved torpedo, Italy.—**Cercle**, August 23.
A new invention in torpedoes.—**Seewesens**, No. 9.
Detailed account of improvements and modifications in cannon and small-arms.—**Kriegswaffen**, No. 11.
Von Löbells reports on changes and progress in military matters during 1895.—**Jour. R. U. S. I.**, August.

BALLISTICS, RANGE FINDING, AND POINTING.

The equations of interior ballistics.—**M. des Poudres et Salpêtres**, 1895-96.
A ballistic problem in the field.—**Cientifico**, July 1.
Some ballistic experiments with siege and field artillery.—**Porvenir**, June 1.
The ballistic qualities of the Swiss rifle, model 1889.—**S. Zeitschrift**, August.
The hyperbola as a ballistic curve.—**Archiv**, May-June.
Motion of ogival projectiles.—**M. de Art.**, June.
Resistance of the air to the motion of oblong projectiles as influenced by the shape of the head (Ingalls).—**Mitth. Art. und G.**, No. 7.
Law of the resistance of the air according to thermodynamics.—**A. Belge**, July-August.
On the resistance of the air to the motion of projectiles, (Siacci).—**Archiv**, May-June, July-August.
An improved telemeter.—**Sien. Amer.**, September 5.
On range-finders.—**Mitth. Art. und G.**, Nos. 5 and 6.
Universal instrument for dividing angles.—**Mitth. Art. und G.**, Nos. 5 and 6.
The Lugeol micrometer with the Lorieux quadrant (range finding).—**R. de Marina**, May 31.
Measurement of distances.—**Z. Arkitekten Vereines**, July 10, 17.
The use of the Hahn range-finder for determination of deviation for wind and movement of target, etc.—**Rundschau**, September.
Field range-finders in European Armies: England, Austria, Belgium, France, Germany, Italy, Russia.—**Mil. Information Div.**, No. 9.
Sights for military rifles.—**A. and N. Journal**, July 11.
The new Lyman military sights.—**Arms and Expl.**, August.
Captain Gaynor's automatic sight.—**Eng.**, August 14.
Sight for indirect firing.—**Mitth. Art. und G**, Nos. 5 and 6.
Automatic pointing in sea coast guns.—**Mitth. Art. und G.**, No. 7.
Laying ahead.—**Mil. Information Div.**, No. 9.
System of aiming and pointing for field and siege guns.—**R. Artig.**, June.
Sight in relation to aiming.—**R. Artig.**, July.

Shrapnel fire, howitzers and field mortars.—**R. Artig.**, June.
Shrapnel from field guns with curved fire.—**Archiv**, February.
Range-tables for mortars and howitzers, (V. Scheve).—**Archiv**, May-June.
Firing big guns.—**Scien. Amer.**, September 5.

METALLURGY.

American blast furnace practice.—**Eng.**, July 10, 24.
The American blast furnace.—**Eng.**, September 4.
Dauber's gas blast furnace.—**Iron World**, August 21.
Microscopic internal flaws inducing fracture in steel.—**Engineering**, July 10, 17, 24.
Iron and steel hardening.—**Iron World**, August 14.
Sand blast apparatus for cleaning castings.—**Cas. Mag.**, August.
The use of power hammers.—**Cas. Mag.**, August.
Brittle materials under compressive stress (Johnson).—**Digest**, July.
Professor Tetmajer's criterion.—**Digest**, July.
Diagrams showing effect of alternate extension and compression on cast iron.—**Digest**, July.
Mobility of molecules in cast iron.—**Digest**, July.
Riehlé U. S. standard automatic and autographic testing machine, 200,000 pounds.—**Digest**, July.
A new method of determining carbon in iron.—**Eng. and Min. Jour.**, August 22.
The physics of cast-iron (discussion).—**Trans. Inst. Min. Eng.**
Notes on the Walrand-Legéuisel steel-casting process.—**Trans. Inst. Min. Eng.**
The Bertrand-Thiel open hearth process.—**Trans. Inst. Min. Eng.**
The microstructure of steel and current theories of hardening.—**Trans. Inst. Min. Eng.**
Determinations of phosphorous in steel.—**Trans. Inst. Min. Eng.**
Practical notes on the properties of iron and steel in constructions.—**Génie M.**, June.
The elastic resistance of tubes of circular cross-section.—**R. Artig.**, June.

ELECTRICITY AND HYDRAULICS.

The electric ignition of blasting explosives.—**Arms and Expl.**, September.
Naval uses of electricity.—**U. S. Gazette**, September 5.
Electrical defenses at Buluwayo, Matabele war.—**Elec. Eng.**, August 5.
An electrically operated bicycle factory.—**Iron Age**, July 30.
An electric chronograph.—**Scien. Amer.**, August 8.
Electric accumulators and their use.—**Génie M.**, July.
The military telegraph in France.—**Wochenblatt**, September 2.
Hardening steel by electricity.—**Elec. Rev.**, September 2.
Electrically worked turrets, Canet system.—**Génie C.**, July 4.

FORTIFICATIONS.

Cement tests.—**Trans. Can. S. Eng.**, December, 1895.
The elevation of sites for batteries.—**Jour. M. S. I.**, September.
Coppée on bank revetment.—**Trans. A. S. Egrs.**, July.
Effect of ship fire against fortifications.—**Cientifico**, June 15.
Fortifications of the port and city of Rio Janeiro.—**R. da Commissao**, May.

BICYCLES—AEROSTATION—PHOTOGRAPHY.

SMALL ARMS AND EQUIPMENTS.

* Other reprints of articles in the *Journal* not heretofore noted are:
Mr. Sturtevant's, in *Marine Rundschau*; Captain Ingalls' in *Mittheilungen über Gegenstände des Artillerie und Genie-Wesens*: A complete and accurate translation by Captain Fellmar, 3rd Royal Saxon Field Artillery Regiment No. 32.

MILITARY GEOGRAPHY.

MILITARY SCHOOLS.

The Saint Cyr examinations.—**Avenir**, June 12.
The naval academy at Nicolaieff.—**Marine F.**, August 25.
Cavalry schools in France.—**Cercle**, July 4, (concluded August 22.)
The royal military college (England).—**A. and N. Gazette**, July 4.

WARSHIPS AND TORPEDO BOATS.

Trial of the *Brooklyn*.—**A. and N. Jour.**, August 22.
Three new battleships, U. S.—**Eng. N. Y.**, September 12.
Classification of naval vessels.—**Eng. N. Y.**, August 15.
Types of U. S. warships.—**Iron Age**, August 27.
Speed trials of U. S. cruiser *Brooklyn*.—**Iron Age**, September 3.
The gun-power of our battleships.—**Iron Age**, August 13.
Contract trial of the U. S. battleship *Oregon*.—**A. S. N. Engrs.**, August.
U. S. battleship *Indiana*.—**Scien. Amer.**, August 15, 22.
The *Brooklyn's* great run.—**Scien. Amer.**, September 5.
The new American battleships.—**Génie C.**, July 25.
The Argentine cruiser *Buenos Aires*.—**Eng. N. Y.**, July 18.
Engines of the *Buenos Aires*.—**Eng. N. Y.**, July 18.
Argentine cruiser *Buenos Aires*.—**Eng.**, July 31.
Argentine cruiser *Garibaldi*.—**Eng'ing**, July 10.
The *Santa Fé*, torpedo-boat destroyer.—**Eng.**, July 31.
Trial of the torpedo-boat *Almirante Simpson*, for the Chilian navy.—**Eng.**, July 31.
H. M. S. *Cæsar*.—**Eng.**, September 4.
The battleship *Cæsar*.—**A. and N. Gazette**, September 5.
The trials of the *Eclipse*, the *Hardy*, and the *Terrible*.—**Marine F.**, August 10.
The launching of the *Isis*.—**Marine F.**, August 10.
English cruiser *Renown*.—**Yacht**, August 1.
English cruiser *Doris*.—**Yacht**, August 1.
H. M. S. torpedo-boat *Janus*.—**Eng'ing**, July 24 31.
Engines of the *Janus*.—**Eng.**, August 29.
The armored cruiser *Amiral Pothuau*.—**Yacht**, August 15.
French battleship *Jauréguiberry*.—**Eng'ing**, July 3.
The *Goubet II.* submarine boat.—**R. de Marina**, July.
Trials of the *Kaiserin-Augusta*, 1895.—**Rundschau**, July.
Development in design and construction of ships of the German navy.—**Rundschau**, August.
Development in design and construction of German men-of-war.—**A. S. N. Engrs.**, August.
Design and construction of German war-vessels.—**U. S. Gazette**, August 1.
The development of German ship-building.—**Seewesens**, No. 9.
Ship-building in Germany.—**Rundschau**, August.
Remarks on the note of M. G. Hart on large cruisers of various powers.—**Ingénieurs Civils**, July.
The Japanese battleship *Yashima*.—**R. Maritime**, July.
Progress of the Japanese battleship *Fugi*.—**Eng.**, September 4.
The battleship of the future.—**Marine F.**, July 10.
Ventilation in warships.—**Eng.**, July 31.
Notes on the ventilation of naval vessels.—**R. Maritt.**, August-September.
Note on oil fuel for warships.—**Eng'ing**, August 29.
A new fuel.—**Marine F.**, August 10.
Classification of warships.—**U. S. Gazette**, August 28, September 5.

MISCELLANEOUS.

NOVEMBER—DECEMBER.

VOL. VI. No. 3. Whole No. 25.

1896.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS

UNITED STATES ARTILLERY SCHOOL.

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School.

COMMITTEE ON DIRECTION AND PUBLICATION.

Captain James M. Ingalls, 1st U. S. Artillery.
Lieutenant Erasmus M. Weaver, 2nd U. S. Artillery.
*Lieutenant George O. Squier, 3rd U. S. Artillery.
Lieutenant Edgar Russel, 5th U. S. Artillery.

EDITOR.

Lieutenant John P. Wisser, 1st U. S. Artillery.

ASSISTANT EDITOR.

Lieutenant Andrew Hero, Jr., 4th U. S. Artillery.

Subscription $2.50
For countries in the postal union $3.00
Single numbers $0.50
Remittances should be sent to the editor at Fort Monroe, Va.

AGENTS.

NEW YORK.—*Hyman & Pfeiffer*, successors to
F. W. Christern, 254 5th Avenue.
LONDON.—*B. F. Stevens*, 4 Trafalgar Square.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. VI. No. 3. NOVEMBER—DECEMBER, 1896. WHOLE No. 23.

THE NEW POLARIZING PHOTO-CHRONOGRAPH AT THE U. S. ARTILLERY SCHOOL, FORT MONROE, VA., AND SOME EXPERIMENTS WITH IT.

A Report to the Board of Ordnance and Fortification, U. S. A.,

BY

DR. ALBERT CUSHING CREHORE,

ASSISTANT PROFESSOR OF PHYSICS, DARTMOUTH COLLEGE,

AND

DR. GEORGE OWEN SQUIER,

FIRST LIEUTENANT, THIRD ARTILLERY, U. S. A.,

Instructor Department of Electricity and Mines, U. S. Artillery School.

It was stated at the close of a previous paper* that the Polarizing Photo-Chronograph authorized by the Board of Ordnance and Fortification, U. S. A., for the U. S. Artillery School, was then nearly completed.

The object of this paper is to describe this instrument and its installation, together with some of the further tests and experiments with it which were carried out in the electrical laboratory of the school where the new instrument was installed during the months of July and August, 1896. It is a pleasure to record at the outset our obligations to Mr. J. A. Brashear of Allegheny, , who constructed the chronograph, and to Messrs. Warner Swasey of Cleveland, Ohio, who constructed the measuring trument for the same.

'he well known reputation of each of these firms in their ticular lines of work has more than been sustained, and their

xperimental determination of the motion of projectiles inside the bore of a gun with 'olarizing Photo-Chronograph.—*Journal of the U. S. Artillery*, May-June, 1896.

skill in execution as well as their experience in methods has contributed no small share in making the instrument what it is at present.

In arriving at the general form which the new instrument has assumed, naturally many radical departures from the form with which the first experiments were conducted were considered, and constructions of the camera which would permit of greater possible length of record, such as wrapping a sensitive film upon a cylinder or by causing the record to assume a spiral form upon a plane sensitive plate, which would suggest themselves almost immediately, were discarded as introducing complications of construction unnecessary for the particular object for which this form of instrument was intended, and the advantages of the general form of a movable plane glass sensitive plate appear more and more apparent with increase of experience.

Since the primary object of this apparatus is the accurate measurement of very minute intervals of time, its particular sphere of merit is in the quantitative investigation of natural phenomena beyond the reach of other methods of measurement, and where the whole period within which measurements are sought is *itself* a small interval of time when compared with a second, for instance.

For this reason, great length of available record, which means roughly comparatively long intervals of time, is unnecessary for the very rapid phenomena which are usually met with in scientific gunnery.

Description of Chronograph.

The essential features of the chronograph as explained in the first paper,* to which reference is made, are the transmitter and the receiver. The former consists naturally of a series of lenses and prisms in the same line with the arc light and tube, so that it makes the apparatus long as compared with the width. In fact it is made like an optical bench, a very convenient form being the inverted T-rail shown at *O* and *O'*, Figs. 1, 2 and 3. Fig. 1 shows the general arrangement of the parts of the apparatus in plan and elevation. Figs. 2 and 3 are views of the instrument in which the lettering corresponds to that of Fig. 1. Upon the rail *O'* are first the arc lamp *a*, one of J. B. Colt's lamps, and in front of it the condensing lens *L*. The polarizer *P* is between the lens *L* and and tube *T* and immediately after the tube is the analyzer *A* and lens *L'*.

* *Journal of the U. S. Artillery*, Vol. IV, No. 3.

The receiver has the form of a sensitized glass plate revolving in its plate holder, which is itself mounted in a heavy cast-iron fly wheel *W*. Both receiver and transmitter are assembled upon the same cast-iron base plate, which is 7 feet 3½ inches long by 2 feet wide. The second **T**-rail seen at *O* carries the accessories for the tuning fork which makes its record upon the sensitive plate on the opposite side to that where the chronograph record appears. Inasmuch as uniform velocity is always used in taking records, it can make no difference where the tuning fork record is placed. This rail *O* carries first a mirror *M* which reflects the light from the arc and turns it in a line parallel with the rail. It then passes through a large condensing lens L'', and an image of the arc is formed upon a small piece of aluminum foil attached to one prong of the tuning fork *F*. This foil has a small round hole in it about one mm. in diameter which is brightly illuminated by the light. The lens L''' forms a magnified image of this luminous hole upon the moving photographic plate. Both of the **T**-rails travel upon two rails VV', one of which V has a flat top and the other V' a **V**-shaped top, which travels in two **V**-grooves cut one in each **T**-rail. The traversing motion is effected by the hand screws *SSSS*, so that each rail may be moved independently of the other. The track V' with grooves in the rails keeps the whole apparatus always at the same distance from the sensitive plate. The transverse motion of the rails is for the purpose of making either the chronograph or tuning fork records adjustable, so that they may be set at any desired distance from the axis of rotation of the plate. This makes it possible to take several records upon the same plate, a circumstance of great practical convenience.

The camera fly wheel *W* is mounted upon the end of a shaft 1⅛ inches in diameter carried by the ball bearings at *BB*. The detail of this shaft and its bearings is shown in Fig. 4.

The armature of a ⅙ horse power electric motor *m*, manufactured by the Crocker-Wheeler Co., is directly coupled to the camera shaft. The motor is not specially constructed, but is one of their standard commercial types. The wheel is so nicely balanced that it will rest in any position where it is left, but the slightest touch of the hand is sufficient to turn it. The motor is wound for low voltage, about twelve volts being the highest ever needed. The inertia of the wheel is so great that it takes several minutes to attain full speed, and it will run many minutes after the power is cut off before coming to rest.

In describing the camera itself reference is made to the detai

drawings Figs. 5, 6 and 7. A vertical section through camera, wheel, and shaft is seen in Fig. 6. The front elevation of the dark chamber is represented in Fig. 5 and through the camera wheel in Fig. 7. The plate holder is made of metal to accommodate two plates 12 × 12 inches square, and slides through the opening *O* in the wheel (Figs. 6 and 7), upon the track *SS* Fig. 7. The holder is held in position by four thumb screws *C C C C* Fig. 2 to prevent the possibility of its flying out when rapidly rotating.

The front part of the camera, shown in elevation Fig. 5, is a casting *D* bolted to the base plate, and in the form of a ring with a section of such a shape that it surrounds the rotating wheel so as to prevent any light from reaching the sensitive plate when the slide is drawn from the plate holder. The wheel *W* has a flange upon the circumference of it, the section of which just fits the stationary ring *D* making a small clearance, and after the solid cast ring *D* is bolted down the light brass ring *R* is screwed on so as to serve as additional security against outside light. This arrangement has proved to be entirely effectual in preventing fogging of the plates.

The light for the chronograph record is made to pass through a narrow radial slit, and to produce as sharp and definite records as possible, it is desirable to have the slit close to the sensitive plate itself. To support the slit in this position a thin brass plate *E* Fig. 6 is screwed to the back of the ring *D*, covering the whole of it, and thus forming a complete screen preventing any light entering from in front. The detail of this brass partition is shown in Fig. 8. At *G* is the radial slit having upper jaw *J* fixed and edge coinciding with a radius of the wheel. The lower jaw *J'* is pivoted at the center *C* and may be clamped in any position by the thumb screw *H*. The upper edge of *J'* is also a radius of the wheel, and thus this arrangement always insures a radial slit capable of adjustment for any width.

Since the camera slide shutter must fall immediately in front of this slit in the brass partition to shut off all light before and after exposure, it makes it necessary to have no projecting parts on the front of the brass plate which would interfere with the shutter in its fall.

The light from the tuning fork reaches the plate through a round opening *K*. This hole is made in a small slide *N* movable diagonally along a slot *Q*. The slot *Q* is made in a second slide *U*, movable vertically along the guides *XX*. This arrangement permits the adjustment of the hole *K* along a radius of the wheel,

and neither interferes with the jaw *J'* pivoted at the center, nor has any projections which the camera slide might strike in falling. Across the hole *K* in the slide *N* are secured several fine vertical wires, the shadows of which form the centering circles upon the plate, as previously explained.

The Camera Slide Shutter.

In order to control the time of exposure of the slit so that the sensitive plate may not revolve more than once while the slit is open, a camera gravity slide shutter is provided. This shutter is shown in elevation in Fig. 5. It consists of a frame of thin sheet metal *PP'* forming a curtain with an adjustable rectangular opening at *R*.

When this shutter is raised the lower part *P'* normally covers both the radial slit and the opening for the tuning fork record, and is held suspended by an automatic catch upon the armature of a small electro-magnet which is permanently attached to the inside of the ring *D*, with its binding posts on the outside, and is not shown in the figure. To operate the shutter at any distance from the camera, it is only necessary to close an electric circuit passing to the binding posts referred to. Since this shutter has considerable weight, its lower circular edge at *T* is provided with a thick rubber *cushion* extending along the entire lower edge which serves to soften the shock of the fall. In order to prevent the possibility of the shutter rebounding sufficiently to expose the slit a second time, an automatic bevel catch lock is attached to the inside of the ring *D* at its lowest point. In rising and falling the shutter rides between vertical guides *GG*, Fig. 5, upon the four beveled rollers *m m m m*.

The adjustable edge *n* of the shutter can be clamped by means of thumb screws, not shown, at any desired measured distance from the fixed edge *o*, graduated metal scales being marked upon the sides of the frame for the purpose of setting.

The operation of this shutter in opening and closing the radial slit is as follows: The shutter being up, its lower part *P'* closes the slit, and upon being released when it falls a certain fixed distance, the edge *o* first exposes the slit, and it remains exposed until the upper edge *n* closes it in the fall. The total time of exposure may by this means be set for any time ranging from zero to a certain maximum, about a tenth of a second.

To cover the entire front of the camera ring *D* a wooden circular face is provided, which can be removed at pleasure and two small windows upon either side sliding longitudinally in

grooves permit the light for the chronograph and tuning fork records to enter. This cover is simply an additional precaution, and to provide a means of exposing the slit by hand independent of the camera shutter when desired. This cover in position forms an additional small dark chamber in the space between the camera shutter and the front face of the stationary camera ring *D*. In the ordinary use of the camera slide shutter for exposing the plate this wooden cover may be dispensed with.

The Gravity Switch.

The gravity switch and its function in exposing the camera and firing the gun has been explained in the first paper. The form for the new instrument is substantially the same as the rough one made for the first experiments. It is shown at *U*, Figs. 2 and 3; and, for convenience in setting and dropping the firing weight, the central rod along which the square brass cylinder falls is permanently graduated in inches, as also are the side rods which bear the pairs of binding posts for the electric primer and the camera release electro-magnet.

The Plate Holder.

The metal plate holder is inserted at the opening *O*, Fig. 6, in the periphery of the camera wheel *W*, and carries two ordinary commercial sensitive plates 12 by 12 inches which are inserted and withdrawn in the ordinary way. Two thin metal slides are provided which can be withdrawn after the holder is inserted and before the camera wheel is started to revolve. To enable plates of smaller size to be used when desired, each side of the plate holder has a metal nest form which can be inserted and takes an 8 by 10 plate.

Since the plate holder itself possesses considerable mass and is sometimes required to be revolved at high rates of speed, it is desirable to prevent any play between the glass plate and its holder. This is accomplished by tightening thumb screws in the holder which bear against the edge of each plate through the intervention of springs similar to those ordinarily employed in commercial plate holders. As already mentioned, the entire plate holder is firmly secured in position within the camera wheel *W* by four screws *CCCC*, Fig. 2, which pass directly through the side frame of the holder itself.

Tubes and Coils.

The particular shape and size of the tube for the carbon bisulphide, and the constants of the coils to obtain the desired light

upon the plate, depend upon the electromotive force which is employed in the transmitter circuit, and the resistance and inductance of the rest of the circuit including the line.

These conditions being determined, a tube coil can be wound which will be most effective. During the tests of the chronograph, some account of which will follow, several tubes were made and used, but the one suitable for use in the ordinary case of taking velocities, and which was specially made with the chronograph, is shown at *T* Figs. 2 and 3 and is wound of No. 18 cu. wire in four sections having an ohmic resistance in series of 12.7 ohms and in parallel of 0.84 of an ohm.

Inductance of four coils in series = 0.084 henrys.

Inductance of four coils in parallel = 0.0052 henrys.

The Nicol Prisms.

The size of the Nicol Prism used as polarizer is 7.7 cms. long and 2.6 cms. in diameter. This is much larger than the one used as analyzer. The use of the condensing lens in front of the arc light makes it possible to use a much smaller analyzer, since the arc is brought to a focus at a short distance beyond it. The smaller analyzer also has the advantage of absorbing less light on account of its shorter length. The dimensions of the analyzer are 3.6 cms. long and 1.4 cms. in diameter.

Tuning Forks.

A set of eight standard forks were imported from Koenig, Paris, selected as being suitable to cover the range of speeds which would ordinarily be employed for the sensitive plate in actual practice.

There are two each of 250, 500, 1000 and 2000 vibrations per second, one set to be used as standards with which to compare the others when they are used with the aluminum foil attached. The universal mounting for the different forks shown at *F* Figs. 2 and 3 permits of an adjustment of the prongs of the fork for height and also transversely with respect to the optical T-rail.

The lenses L'' and L''', Figs. 1, 2 and 3, besides being adjustable for height as are the other lenses, have also a transverse adjustment to facilitate placing the image of the luminous hole in the foil upon the fork at the exact position desired.

The Mounting of the Chronograph.

To provide a firm support for all the apparatus, a solid brick pier was built upon a concrete foundation placed beneath the floor of the laboratory, and finally the base plate was set and

leveled in suitable cement, and firmly anchored down by four bolts about 4 feet long extending from the four corners of the base plate down beneath the floor.

Process of Developing the Plates.

No simpler manipulations in the art of photography can be imagined than those required in the use of the chronograph. In the first place no prints are ever required, the measurements being made directly from the negatives themselves. Since there are no lights and shades to look out for as in taking ordinary views, where it is sometimes contrast which is desired and sometimes lack of contrast, the process of developing merely consists in pouring the liquid "developer" so as to flow the plate uniformly and quickly, and then rocking the tray until both tuning fork and chronograph records show plainly. The plate is then "fixed" in the ordinary way. Almost any developer may be employed, and there are many different kinds, some being two fluid and others one fluid developer. The two fluids are mixed just before developing. In practice the single fluid is more convenient for it is ready at a moment's notice. Such a developer will keep for months if kept in glass stoppered bottles in the dark room. A formula which gives very satisfactory results is

One Solution Developer.

Water, 100 parts or 10 ounces.
Metol, 1.5 parts or 75 grains.
Sulphite of Soda cryst., 10 parts or 1 ounce.
Sodium Carbonate cryst., 10 parts or 1 ounce.
or substitute for Sodium Carbonate cryst.,
Carbonate of Potash, 5 parts or ½ ounce.

The Metol to be dissolved in water *before* the addition of Sulphite.

This may be diluted with water to suit the work in hand, the formula as given being very strong developer sufficient to cause an ordinary plate to flash up quickly.

Kind of Plates Used.

A rough calculation will show how very short is the time of exposure of any one point on the plate for the chronograph record Supposing the width of slit to be 1 mm. at a distance of 150 mms. from the center of revolution, and that the plate rotates ten times per second, the whole distance travelled by one point on the plate per second is $10 \times 2\pi \times 150 = 3000\pi = 9424.8$ mms. The exposure is therefore .000106 seconds for the point crosses

the millimeter slit in this time. The desirability of having the most sensitive plates which can be made is clearly manifest. It is only the intensity of the light from the arc focused by the condensing lens upon the sensitive plate which makes up for the shortness of the exposure. This instrument affords a convenient way of testing plates; for the conditions may be almost exactly repeated for different plates. The same speed gives the same time of exposure. Some different plates were tried with a view of finding the quickest ones. No plates have been tried which equal the Stanley plate marked sensitometer 50 for quickness. These have consequently been used exclusively for the experiments.

II. THE MEASURING INSTRUMENT FOR THE CHRONOGRAPH.

After the negatives have been obtained by means of the chronograph, in order to determine velocities of a projectile or other moving body, measurements are taken from the negatives. For this particular form of record an angle measuring instrument is required, and a form of instrument specially adapted to the purpose was designed.

A view of this instrument is shown in Figure 9. The parts are assembled upon a cast-iron base plate *A*, 24 by 27 inches, which rests upon three rubber legs, and although ordinarily should be upon a firm pier, it can if desired be easily moved and set upon a table for use at any part of the room. From the center of this base plate *A* is mounted the conical bearing upon which revolves the divided circle, the spokes of which are seen at *SSSS*, as well as the upper plane glass plate *B*, 42½ cms. in diameter and 9 mm. thick, upon which the negatives are mounted when measurements are to be taken. The weight of the glass plate upon the conical bearing is relieved and adjusted by means of a vertical spiral spring in the top of the conical bearing itself.

The plate *B* and the divided circle thus revolve together upon the conical bearing, and can be turned by means of the four arms with spherical mahogany handles shown at *HHHH*, clamped in position by means of the hand screw *J*, and given small motions by the tangent screw *K* with its spring cylinder *L*. By means of the hollow milled screws *N* and *N'* at right angles to each other, and their corresponding spring cylinders *O* and *O'*, the center of the large glass plate *B* has an adjustable motion in a horizontal plane with respect to the vertical axis of the instrument. This is accomplished by having the glass plate *B*

mounted upon a second conical collar of considerably larger internal diameter than the external diameter of the main bearing cone, which collar slides horizontally on a plane surface with respect to the bearing cone, under the control of the screws and springs *N* and *N'* and *O* and *O'*. The object of this independent movement of the plate *B* with respect to the axis of the instrument, is for the purpose of accurately centering the glass negative before readings are made.

The fine circle upon which the measurements are taken is made of silver, and divided by Messrs Warner & Swasey's celebrated circular dividing engine. It has no graduation numbers marked upon it, and is protected from dust by the metal covering shown at *M*, which has its upper face graduated and numbered to read one-half degrees, and, together with a sliding pointer which moves with the glass plate, serves as a rough circle to read angles to half degrees, the finer readings being then taken from the silver circle beneath

Bolted to the base plate are two uprights *DD* which support the cross piece *E* upon which the reading microscope *F* is mounted. This microscope has a motion of translation along a diameter of the glass plate by means of the rack *e* in which works a pinion operated by the thumb screw *f*. This metal track *D'* is screwed to the face of the cross piece *E*, and dove-tailed along top and bottom to receive the bearing frame of the reading microscope. Upon the top of the cross piece *E* two silver scales are mounted side by side, graduated from the central vertical axis outward along a radius in either direction, one reading to $\frac{1}{20}$ of a cm. and the other to $\frac{1}{50}$ of an inch, and by means of two corresponding verniers which move with the reading microscope, the radial distance of any setting can be read to $\frac{1}{500}$ of a mm. or $\frac{1}{1000}$ of an inch.

The Reading Microscope.

The axis of the reading microscope is inclined at an angle of 45° to the vertical axis of the instrument, to permit reading from a sitting position, and thus avoid the strain consequent upon prolonged readings directly from above. This is accomplished by means of an inclined metallic mirror inside the vertical barrel of the microscope which serves to reflect the light from the negative below into the eye of the observer at the eye-piece.

The cross-hairs for the microscope are placed across the lower end of the vertical barrel, that they may be adjusted as near to the negative as possible to give increased accuracy, and since the

glass negatives vary considerably in thickness, the whole microscope can be raised and lowered by means of the thumb screw *g*, and a scale for reading these relative heights is also provided. The system of cross-hairs consists of two sets at right angles to each other, which have a relative motion in azimuth with respect to each other. They are mounted in separate collars at the lower end of the microscope barrel and are approximately in the same plane. By means of two pinions working in two cog wheels seen in the view and operated by two thumb screws *h* and *h'* on either side of the microscope, the two sets of hairs are moved in azimuth at will, and a circular divided scale *ii* reading to two degrees is provided by which the angle between the sets is known.

The advantage of this plan is that any arrangement of four hairs intersecting at a common point, found most convenient for the particular observer, or most desirable for accurate setting upon a particular form of record upon the plate, can be obtained by simply adjusting the thumb screws *h* and *h'* mentioned above. If the two sets are adjusted to coincide we have the ordinary case of but two perpendicular cross wires visible, and from this to intersections at any angle with respect to each other, and also at any angle with respect to the sharp edge of the record which is radial upon the plate, are obtainable.

To make this microscope more elastic and applicable to a wide range of purposes, it is provided with two sets of lenses proper and three different eye-pieces, giving combinations in magnifying power of 3, 7 and 10.

For the purpose of illuminating the negatives to facilitate setting, two plane mirrors, *M'* and *M''*, placed to reflect light directly up through the negative into the microscope, are attached; and by means of the hand screws, *P* and *P'*, these may be adjusted to the proper angle to so reflect the outside light.

The Micrometer Microscopes.

Instead of verniers and magnifying glasses for reading the angles, the much more convenient and accurate micrometer microscopes shown at *R* and *R'* are employed. As in the reading microscope, these are mounted with their axes inclined at an angle of 45° with the vertical axis of the instrument, so that all observations both for angles and for settings upon the record are conveniently performed by the observer from a sitting position and without moving. This is accomplished by means of totally reflecting prisms *S* and *S'*, which reflect the light from below into the eye of the observer at the eye-piece.

Through the outer rough circle *M*, two windows are cut beneath the reflecting prisms of the micrometer microscopes, by which the illumination of the silver scale beneath is obtained from the light passing through the translucent glass cylinders *T* and *T'*, and through these windows is the only way by which this scale can be observed. To prevent any particles of dust from collecting inside the tube, the lower end of each of the translucent glass cylinders is provided with a circular cloth screen extending to the surface of the outer scale circle *M*. These are shown at *u* and *u'*.

To enable the instrument to be used at night as well as in daylight, the translucent cylinders can be artificially lighted by means of two small incandescent electric lamps shown at *V* and *V'*. These lamps require about five volts and one-half an ampere to secure a good illumination of the scale beneath.

The silver scale is divided to read to tenths of a degree. The decimal division of a degree is preferred to minutes and seconds, because if the readings were taken in minutes and seconds, they would have to be reduced to the decimal system in computing velocities.

The micrometers *W W'* are divided into twenty parts, and since five revolutions of the micrometer screw correspond to one small division upon the scale beneath, the micrometer reads directly to one thousandth of a degree, and by estimation to tenths, to one ten-thousandth of a degree.

Centering the Glass Negative.

The circles which appear upon the tuning fork records and are produced by the fine wires in the camera already described, are for the purpose of accurately centering the plate before any measurements are taken. This obviates any necessity for centering the plate itself when in position in the camera.

The negative is laid film side up upon the glass plate *B*, approximately centered and held in position by the four spring clamps *c c c c*. By means of the traversing screw (*f*) the reading microscope is moved until the tuning fork record comes in the field of view, and then by means of the hand screws *N* and *N'*, the plate *B* with negative is moved until the intersection of the cross hairs remains upon any one of the circles of the record during an entire revolution of the plate. The negative being then centered the reading microscope may be traversed to show the chronograph record, and the setting made for the final readings of the angle by means of the micrometer microscopes already explained.

In considering this instrument as a whole, it is evident that it has a wide range of use other than that for which it was particularly constructed. How it can be employed either to divide or to test the division of graduated circles will readily be seen by those interested, and the convenience and arrangement of the various parts, and especially their simplicity, it is thought will commend this form of angle measuring instrument for a general laboratory apparatus.

III. SOME FURTHER EXPERIMENTS WITH THE CHRONOGRAPH.

During the progress of the installation and testing of the new instrument an opportunity was presented for some further experiments with it, both along the line of simplification in manipulation when used for the single purpose of measuring projectile velocities, and also some other experiments of a more purely physical interest.

The design of the chronograph is such that it may be used for a variety of purposes not only as a chronograph, but also as an instrument for the investigation of problems which are met with in the laboratory, such as the study of alternating current phenomena, the study of the rate of motion of almost any body, the recoil of gun carriages, and many others which suggest themselves to the reader. The pleasure experienced in using a well made instrument with all its fine adjustments, can well be appreciated after one has been obliged to use the home made apparatus with which the original investigations were made.

The source of power which was permanently installed to operate the chronograph consists of 38 storage cells, which are charged at regular intervals by an Edison dynamo driven by a steam engine. The use of these cells for the chronograph does not prevent them from being available for the general laboratory uses of the Artillery School, as well as for furnishing the electric lighting for the electrical and chemical laboratories, the machine shops, boiler houses, and also for operating the two Boulengé chronographs already at the post (thus supplanting the Edison-Lalande battery), the post telegraph and fire alarm systems (supplanting the large number of gravity cells formerly used), besides electric fans, etc.

Since the storage cell has an internal electrical resistance practically *nil*, they can be drawn upon independently for all these purposes at the same time, or by means of a general switch board each circuit can be cut out or in at pleasure.

Two new No. 8 copper line wires, extending from the instrument to the new 10-inch disappearing gun battery about 1100 yards distant, have been put up and are ready for use.

Exterior Velocities with the 3."2 Field Gun.

For the purpose of the preliminary tests with the new instrument and to determine the constants of the gravity switch, the field gun was again utilized as being most convenient, and on August 4th, 1896, the first actual velocity was taken. But four screens were employed and these were placed at about ten foot intervals. The revolutions of the plate were 658 per minute, and the strength of current employed for the transmitter circuit, the four sections of the tube coil being joined in parallel, was 13½ amperes. The same construction of screens and means of restoring the transmitter circuit between screens was employed as is described in the first paper, and were all that could be desired for the purpose. The general appearance of the record is the same as has been shown in previous records, except that with a sensitive plate twelve inches square the linear distance between consecutive records, representing ten feet on the proving ground, is much greater than formerly, and permits therefore even greater accuracy in measurement.

Simplification in the use of the Instrument for Projectile Velocities.

To avoid the necessity of being obliged to cause the projectile records communicated by the transmitter to occur during the passage of the camera drop shutter in its fall, which limits the total time of exposure of the plate, it is very desirable to be able to dispense with this shutter in ordinary practice in simply taking velocities, employing only the crossed Nicols to prevent the light beam from entering the slit before the transmitter circuit is made.

We are thus relieved of any uncertainty due to non-uniformity in the action of electric primers, or the difference in the "time interval" between the making of the primer circuit and the projectile reaching the muzzle for different guns, which intervals though ordinarily considered small are not so when compared with such intervals as are met with in ballistic experiments; and we are assured that whatever happens in the transmitter circuit *will surely* be shown upon the plate in any case, no matter what gun is being used.

If we also have some means of controlling the exposure of the

tuning fork record without operating the camera shutter, and causing this record to be made upon the plate simultaneously with the chronograph records, we have an ideal simplicity in operation for taking projectile velocities.

A method which has been shown by trials to be entirely satisfactory is the following: The mounting for the fork F (Figs. 1, 2 and 3) is simply transferred to the same optical T-rail with the lamp and tube and placed between the analyzer and the receiver. The lens L''' which is used upon the fork rail for focussing the luminous hole in the aluminum foil upon the plate, is also placed upon the tube rail, and used to condense the light which comes through the tube upon the edge of one prong of the fork, which is now used without the aluminum foil attached and properly adjusted in the path of the beam so as to intercept one side of it. The short focus lens L' is now used to form a sharp and magnified image of the edge of the fork upon the slit.

By this simple arrangement we see that each chronograph record becomes its *own time record* as well, and when once the fork and the lens L' are adjusted, the operator need have no further concern during a series of observations upon the same plate in regard to securing the time record, other than providing that the fork shall be vibrating at the instant an observation is to be made, and this too is made entirely automatic and perfectly certain of execution.

The available space for other records upon the plate is now more than doubled, and there is no possibility of associating the wrong fork record with any particular gun record, but it desired a long series of observations can be taken without ever removing the plate holder from the camera wheel, and in regular succession from outside inwards or *vice versa*, by simply traversing the rail slightly between shots by turning the traversing hand screws provided for the purpose.

When it is desired to use the camera in this manner without operating the drop shutter provided, it is only necessary to secure the shutter temporarily in any position so that its opening R Fig. 5 shall uncover the slit, and to close entirely the round opening for the fork record on the opposite side shown at K Fig. 8, shift the slides, N and U until this obtains.

To prevent the daylight of the room from fogging the plate through the open slit; and it would have an especial opportunity if the slit should be exposed to it during several revolutions of the plate before the gun was fired, it is desirable to provide means by which the time between the instant at which the gun is

fired and the slit itself exposed shall be as short as possible, and fortunately this is accomplished very easily.

All that is necessary is to pull a simple hand switch which will close the transmitter circuit, to admit the light through the tube upon the plate, at the same time that the primer circuit is closed to fire the gun. The same battery which is used for the tube is also used to fire the primer.

From this it is but a natural step to attach to this same lever the wedge which plucks the fork, and we have reached the point at which the whole operation of taking with certainty observations for velocities at any number of prepared points either outside or inside the gun consists in simply moving one hand lever.

The lamp is kept adjusted and the camera wheel constantly revolving so that whenever the telephone from the proving ground announces that the shot can be fired, the chronograph operator accomplishes all with the simple act above described. Furthermore this plan permits of all this information being recorded upon the plate by means of but *two line wires* from the chronograph to the gun, which may be any desired distance away, because the same wires may now serve for the primer and transmitter circuits, they being closed at the same time by the movement of the firing lever. By this means we have upon each record the additional information of the exact "time interval" between the making of the primer circuit and the instant the projectile reaches the muzzle or first prepared screen, which "time interval" varies for different guns, kinds of powder, &c., and is a constant itself of considerable importance, especially in naval gunnery from a rolling platform.

Numerous tests were first made to prove by actual trials whether when the Nicols were set for extinction, this served as a sufficient screen to prevent the powerful beam condensed down the tube, from still being able to fog the plate after a time sufficient for several revolutions of the plate, as also to determine to what extent the ordinary daylight of a room must be screened off to secure clear records without traces of fog The small slide windows in the wooden face cover of the camera, are convenient means of making the exposure by hand when the *inside drop shutter* is not operated.

In Fig. 10 are shown some of the "combination records" by the method described above in which the tuning fork 250 (single) vibrations per second is employed. The plate was revolved slowly by hand which accounts for the saw-tooth appearance of

the record. The exposure for this plate was made by the slide window above referred to.

Fig. 11 shows part of an actual velocity record by this plan with the 3".2 gun, in which the tuning fork 500 (single) vibrations per second was used. The four sections of the tube coil were joined in series and a current of seven amperes used in the transmitter circuit to increase the amount of light through the analyzer.

Second Method.

Another way to accomplish the result above described has some advantages over the one just mentioned; for this allows a tuning fork record to be taken as formerly. The former tuning fork records with their fine intersection points by which measurements are made are difficult to improve upon, and some advantage is gained by retaining it. This may be done by having the shutter for the tuning fork record work independently of that for the chronograph record. The chronograph shutter is then left permanently open, and only the Nicol prisms and tube used for a shutter as previously described. The gravity shutter is used for the tuning fork which is released when the lever is pulled to fire the gun. This gives an independent time record as formerly, and if many exposures are made on the same plate care must be taken to be sure which records go together.

The chronograph record with the exception of the one wavy edge will be the same as last described. The transmitter circuit is made with the primer circuit, and the "time interval" of the particular gun used is recorded on the plate as before.

SOME CHRONOGRAPH EXPERIMENTS WITH ALTERNATING CURRENTS.

The enormous commercial development of alternating currents during the past few years has necessitated a thorough study of the phenomena connected thereto. The great difficulty which has stood in the way of experimentally recording by a continuous method, not a method by points, the instantaneous values of an alternating electric current which is changing its direction hundreds of times a second, at present constantly met with in practice, has prevented in a great measure direct experimental evidence being obtained to verify and corroborate many of the conditions which theory points out should exist.

This experimental problem becomes much more difficult, when we attempt to determine and record what happens in a circuit carrying an alternating current, when it is suddenly altered in

some way, as for instance when it is made or broken. The fluctuation of the current under varying conditions of the circuit as to its resistance, inductance and capacity when the circuit is made, has been theoretically deduced when the electromotive force is truly harmonic, and this case is especially worthy of experimental evidence.

Any "method by points" depends fundamentally upon the supposition that the fluctuations in current repeat themselves exactly in successive alternations, and evidently this is far from being true for the important cases just mentioned.

The employment of a continuous method of recording, not involving the movement of any *ponderable matter*, and therefore without inertia in the production of the record, which is the fundamental principle of this chronograph, gives indications therefore in accurate phase with the fluctuating current, no matter how rapid these changes may occur, and since the time scale is also accurately recorded upon the plate by means of the tuning fork record, we may consider each negative obtained as a qualitative graphical representation of the varying current, automatically plotted in terms of the two variables, time and intensity.

It is true that the values of intensity shown are not to scale, nor is the law of its actual intensity variation definitely shown upon the negative, but nevertheless the main features of the problem are recorded, and these are more often all that are desired. For instance, whenever the current is zero there is no magnetic field within the tube solenoid, and consequently no rotation of the plane of polarization of the beam, and therefore no light upon the plate.

Between the points of zero and 90° rotation, it can be said that the intensity of light which reaches the plate varies in a general way with the sine of the angle of rotation. As is well known however, what has been said only strictly applies to monochromatic light and to the intensity of light which reaches the plate, not to the photographic record produced by it, since from the researches of Verdet and others it is known that the component rays of white light are rotated by a given magnetic field in different amounts, and in fact this rotation depends not only upon the wave length, but upon the index of refraction of the particular medium corresponding to that wave length, and also upon the rate of change of the index with respect to the wave length. Furthermore it is known that the actinic value in producing photographic results is not the same throughout the spectrum, but is richer in the blue end.

These refinements however possess little significance when we are concerned only with the general features of the problem, and care less about absolute values of the varying current as in the case at hand.

Apparatus employed.

The principal source of power for alternating current work at hand in the laboratory, is a 300 light Fort Wayne ten-pole alternator, producing a difference of potential at its terminals of a thousand volts. By means of a bank of commercial transformers this voltage is reduced as desired for ordinary experimental purposes. An alternating source of potential of about 300 volts was usually employed in the experiments to follow, as being safe enough to handle and high enough to secure good results upon the plate.

This voltage was obtained by joining in series the secondary coils of five transformers ranging in voltages from 50 to 100, their primary coils being as usual each connected to the dynamo mains. A measured voltage of 304 at normal speed was thus obtained for use. The inductances of these secondary coils were measured to be as follows:

Secondary	coil	No. 1	Transformer	.0435	henrys
"	"	No. 2	"	.0831	"
"	"	No. 3	"	.0431	"
"	"	No. 4	"	.0605	"
"	"	No. 5	"	.1399	"

Total inductance $= 0.3701 = \Sigma L$

To obtain the requisite number of ampere turns around the tube to produce good results for a given source of impressed alternating E.M.F., it is necessary to consider not only the ohmic resistances of the line and the coil itself, but also the inductances of the line, transformer secondary coils and tube coil, as well as any capacity that may be present or introduced into the circuit. Accordingly the source of alternating E.M.F. being determined, suitable transmitter coils were designed and made for these experiments, the constants of which are given below.

Coil A.

Size of copper wire No. 36 single silk covered.
Length of coil, 36.2 centimeters.
Numbers of turns, 13,670.
Resistance, 1,310 ohms.
Inductance, .875 henrys.

Dimensions of carbon bisulphide tube for Coil A:
Total length of glass tube, 40 cms.
Outside diameter, 2 cms.
Inside diameter, 1.5 cms.

Coil B.

Size of copper wire, No. 28 double cotton covered.
Length of coil, 36.5 centimeters.
Number of turns, 11,168.
Resistance, 390 ohms.
Inductance, 0.66 henrys.

Dimensions of carbon bisulphide tube for Coil B:
Total length of glass tube, 39.5 cms.
Outside diameter, 2.5 cms.
Inside diameter, 2 cms.

The first experiments were to obtain records upon the camera plate of the simple alternating current, and to note the effect of variations of speed of the plate and width of slit upon the appearance of the record. Fig. 12 exhibits a number of such records and illustrates the variations referred to. The speed of the generator was such that the transmitter current had a frequency of about 137 periods per second, and to avoid drawing out the records too much, most of the exposures were taken with the camera wheel revolved slowly by hand instead of using the electric motor.

In the figure there are seven different exposures made on the same plate by moving the T-rail of the chronograph each time, so that the beam of light strikes the plate at different distances from the center. The exposures are purposely made under different conditions, merely to illustrate the different appearance which the records assume. The circuit in each instance contains Coil B above described, and the source of supply of current was the secondaries of five transformers joined in series, giving a total of 300 volts at frequency 137 complete alternations per second. Beginning at the outside the records may be thus described.

1. The camera slit was comparatively wide, the speed of rotation moderate. No condensers in circuit.
2. Slit same width, speed somewhat faster. Three condensers are inserted in series with the circuit, making a capacity of 4.785 micro-farads.
3. Same circuit as 2 above, but camera slit is narrower. Speed of plate is decreased.

4. Same circuit as 2 above, slit wide, speed increased considerably.
5. Same circuit as 2 above. Narrowest slit of all. Plate moved very slowly.
6. Same circuit. Very narrow slit. Speed moderate.
7. No condensers in circuit. Very wide slit. Faster speed of plate. In this case the plate went more than once around making a double exposure.

The ammeter-voltmeter method was used to measure the inductances of the coils above referred to, which may be illustrated by the case of Coil B.

The equation for current in a circuit containing an alternating E.M.F with resistance, inductance and capacity is

$$(1) \qquad I = \frac{E}{J} = \frac{E}{\sqrt{R^2 + \left(\frac{1}{C\omega} - L\omega\right)^2}},$$

in which the impedance J, is made up of two terms, the ohmic resistance R and the reactance $\frac{1}{C\omega} - L\omega$. In the case of coil B since there is no capacity in the circuit, the reactance is entirely inductive and reduces to $L\omega$. Making this simplification and solving for L we write

$$(2) \qquad L = \frac{1}{\omega}\sqrt{\frac{E^2}{I^2} - R^2},$$

in which the second member contains only measurable quantities.

$\omega = 2\pi n$, in which n equals the number of complete cycles per second. The speed of the generator was such that $n = 139$ and $\omega = 873$. $E = 84.5$ obtained from voltmeter reading at terminals of the coil.

$R = 390$ ohms measured by Wheatstone bridge.

Since the current I was too small to be directly measured with the alternating current ammeters at hand, resort was made to the voltmeter for the current value also. A non-inductive resistance of 144 ohms, consisting of incandescent lamps was joined in series with the circuit, and the voltmeter reading taken at the terminals of this resistance was $= 17.5$.

We then have

$$I = \frac{17.5}{144} = 0.1214 \text{ amperes.}$$

Substituting these measured values in (2) above we have

$$L = \frac{1}{878}\sqrt{\frac{84.5^2}{.1214^2} - 390^2}$$

$$= 0.66 \text{ henrys.}$$

The capacity at hand for use in these experiments was a set of six commercial Stanley condensers, capable of standing continuously 500 volts alternating. These condensers were alike, each having a measured capacity as follows:

The six condensers were themselves joined in parallel, and then connected in series with an ammeter directly to the transformer terminals.

Equation (1) for this case, where R and L are each zero, becomes

$$I = \frac{E}{\frac{1}{C\omega}} = C\omega E$$

$$C = \frac{I}{E\omega}.$$

Simultaneous ammeter and voltmeter readings gave $I = 2.5$ and $E = 304$, and the speed of the alternator was such as to make $\omega = 860$. We therefore have

$$C = \frac{2.5}{304 \times 860} = 9.57 \times 10^{-6} \text{ farads,}$$

$= 9.57$ microfarads $=$ capacity of six condensers in parallel.

$\therefore$ Capacity of each condenser $= 1.595$ microfarads.

EXPERIMENTS UPON CURRENTS AT THE "MAKE" FOR AN HARMONIC E. M. F.

A number of negatives were taken with the chronograph, to verify the results of theory in the interesting case of "make" for an alternating current, or in other words to determine the effects upon the current during the very short interval of time after the harmonic electromotive force is suddenly introduced into the circuit.

Transmitter circuits were made up containing resistance, inductance, and capacity in varying proportions, and the effects recorded upon the plate upon making the circuit.

When any electric circuit is closed, the moment at which actual contact is made is usually a very short interval of time as compared with the period of alternation of any ordinary alternator.

Evidently then the circuit may be closed when the harmonic electromotive force is at any point of its phase, that is it may be zero, may have its maximum value, or any intermediate value.

The effect upon the flow of current for a given circuit, is known to depend among other things, upon the phase of the electromotive force at the instant the circuit is made. Figs. 13 to 18 show some of the results where the circuit is made, which are in accord with what theory* indicates.

Figs. 13, 14, and 15, show different exposures for a circuit including chronograph tube coil B, the secondaries of the 5 transformers, and the 6 Stanley condensers in parallel with each other and in series with the circuit, under similar circumstances of "make."

The constants of this circuit were,

Circuit I.

$$\Sigma L = 0.37 + 0.66 = 1.03 \text{ henrys},$$
$$\Sigma C = 9.57 \times 10^{-6} \text{ farads},$$
$$\Sigma R = 390 \text{ ohms}.$$

$$E = 300 \text{ volts} = 300 \times 10^{8} \ C.G.S. \text{ units},$$
$$R = 390 \text{ ohms} = 390 \times 10^{9} \ C.G.S. \text{ units},$$
$$L = 1.03 \text{ henrys} = 1.03 \times 10^{9} \ C.G.S. \text{ units}.$$
$$C = 9.57 \text{ microfarads} = 9.57 \times 10^{-15} \ C.G.S. \text{ units},$$
$$\omega = 865.$$

The general expression for the instantaneous value of the current flowing in any circuit containing resistance, inductance and capacity is given by the equation

$$(1) \quad i = \frac{E}{\sqrt{R^2 + \left(\frac{1}{C\omega} - L\omega\right)^2}} \sin \left\{ \omega t + \text{arc-tan} \left(\frac{1}{R\,C\omega} - \frac{L\omega}{R} \right) \right\}$$
$$+ C_1 \varepsilon^{-\frac{t}{T_1}} + C_2 \varepsilon^{-\frac{t}{T_2}},$$

in which C_1 and C_2 are arbitrary constants, and T_1 and T_2 are the time-constants of the circuit. Usually the last two terms of this equation are not written, for when the alternating current has reached a steady state the value of these terms become inappreciable. This steady state is usually reached in a very few oscillations after the "make," but in the present investigation it is the effect of these exponential terms at the "make" which it is desired to study. The values of the time-constants T_1 and T_2 depend upon the constants of the circuit R, L, and C, according to the equations

* The discussion of currents at the "make" for an harmonic E. M. F. may be found in Alternating Currents, Bedell and Crehore. W. J. Johnston Company, New York.

$$T_1 = \frac{2LC}{RC - \sqrt{R^2C^2 - 4LC}},$$

$$T_2 = \frac{2LC}{RC + \sqrt{R^2C^2 - 4LC}}.$$

It sometimes happens that the constants are such that the values of the time-constants T_1 and T_2 have imaginary forms. This is the case when $4L$ is greater than R^2C. It has been shown however that, when these time-constants assume the imaginary form, the two terms at the end of equation (1) above, when taken together may be expressed in a real form involving a sine function instead of an exponential. This form may be written

$$(2) \qquad A\epsilon^{-\frac{Rt}{2L}} \sin\left\{\frac{\sqrt{4LC - R^2C^2}}{2LC}\,t + \Phi\right\},$$

Where A and Φ are the arbitrary constants instead of C_1 and C_2 above. The coefficient of t in this expression is equal to 2π times the *natural* frequency of oscillation of the circuit, and if denoted by a, the above expression becomes

$$(3) \qquad A\epsilon^{-\frac{Rt}{2L}} \sin\left\{at + \Phi\right\}.$$

Writing in equation (1) the abbreviated values

$$(4) \qquad I = \frac{E}{\sqrt{R^2 + \left(\frac{1}{C\omega} - L\omega\right)^2}},$$

and

$$(5) \qquad \theta = \text{arc-tan}\left(\frac{1}{RC\omega} - \frac{L\omega}{R}\right),$$

we have

$$(6) \qquad i = I \sin\left\{\omega t + \theta\right\} + A\epsilon^{-\frac{Rt}{2L}} \sin\left\{at + \Phi\right\}.$$

The arbitrary constants A and Φ must be determined according to the physical conditions imposed by the problem. In this equation time is counted from the moment when the harmonic E. M. F. is zero. Physically the circuit may be closed at any instant, and previously to the closing of the circuit no current is flowing. One condition which determines the constants is therefore that, when $i = o$, $t = t_1$, meaning by t_1 the time when the circuit is closed counting from when the E. M. F. is zero. The

charge Q of the condenser is also supposed to be zero when the circuit is made. The angle $\omega t+\theta$ in equation (6) may be denoted by ψ, and if ψ_1 denotes the value of this angle when $t=t_1$, then the equation may be written in full with constants determined according to the above conditions,

$$(7)\quad i=I\sin\psi+\frac{2I\sqrt{(LC\omega^2-1)\sin^2\psi_1+\frac{1}{2}RC\omega\sin 2\psi_1+1}}{\omega\sqrt{4LC-R^2C^2}}\,.$$

$$\epsilon^{-\frac{R}{2L}(t-t_1)}\sin\left\{a(t+t_1)+180^\circ+\text{arc-cot}-\left[\frac{2\cot\psi_1+RC\omega}{\omega\sqrt{4LC-R^2C^2}}\right]\right\}.$$

Physically we may say from an inspection of this equation, that the true current wave is the sum of two simple waves each expressed by a single term in the equation. The first is an harmonic wave, $I\sin\psi$, the current wave which is the final steady form to which the current approaches. This is evident for the second term contains ϵ the Naperian base with a negative exponent, so that as t increases the whole term rapidly decreases until its effect is practically *nil*. The rapidity of this decrease is governed by the value of $\frac{R}{2L}$ found in the exponent of ϵ. Usually these values are such that the rate of decay is very rapid. The coefficient of ϵ which determines the magnitude of the initial value of the logarithmic curve, is seen to depend largely upon the value of ψ_1, that is upon the time t_1, when the circuit is closed. With the same circuit and E. M. F. it is evident that very different results may be obtained by closing the circuit at different times.

The whole second term represents a sinusoidal curve having a logarithmic decrement, and this curve at the time t_1 when $i=o$, must therefore have its initial ordinate equal and opposite to the value of the first term, $I\sin\psi$, of the equation in order to satisfy it.

When the numbers are substituted in equation (7), representing the constants of the circuit previously given we have

$$(8)\qquad i=0.493\sin\psi-0.2435\sqrt{6.4\sin^2\psi_1+1.61\sin 2\psi_1+1}$$

$$\epsilon^{-189(t-t_1)}\sin\left\{237(t-t_1)+180^\circ+\text{arc-cot}-\left[\frac{2\cot\psi_1+3.22}{5.74}\right]\right\}.$$

If the value of t_1 is such as to make $\psi_1=o$ then equation (8) becomes

$$(9) \qquad i = 0.493 \sin \psi + 0.2435 \, \epsilon^{-189(t-t_1)} \sin \left\{ 237 (t - t_1) \right\}$$

The plot of this equation is represented by curve (III) Fig 19. This curve is made up cf two component curves one corresponding to each term of equation (9), the first term giving curve (I) and the second term curve (II). The sum of these curves gives curve (III), which is the resultant curve representing the resultant current equation (9). Curve (I) is a sine curve having a maximum amplitude of 0.493 amperes, and a period of 0.007275 seconds corresponding to the impressed frequency of 137.5. Curve (II) is a sine curve with logarithmic decrement. Its period is comparatively long, being 0.0265 seconds corresponding to the slow frequency of 37.5 per second.

The initial value of the logarithmic curve (IV), is 0.2435 the coefficient of the second term in the equation, and the rate of decay is determined by the exponent — 189, such that the ordinate has $\frac{1}{\epsilon}$th of its initial value after $\frac{1}{189}$ or .0053 of a second. This time-constant is indicated in the figure by a vertical line drawn at the distance .0053.

The phase of oscillation is seen to be zero, that is the logarithmic oscillation begins with its zero value. This is evident for another reason also. The initial value of the curve representing the second term must be equal and opposite to the initial value of that representing the first term, since their sum must give an initial value of zero for the resultant current curve, to fulfill the physical conditions.

A sine wave curve (V) is drawn representing the wave length and amplitude of the oscillation as it would be if not subject to the logarithmic damping. It is of use in constructing curve (II); for the points on curve (II) are found graphically by diminishing the ordinate of the logarthmic curve at any point in the ratio of the ordinate of the sine curve at that point to its maximum value.

The resultant curve (III) representing equation (9) is seen to have first a slightly larger wave than the normal wave, then a considerably smaller one, and the third wave very nearly coincides with the normal wave curve (I), so that beyond the fourth semi-period the disturbance due to the "make" has become imperceptable.

An experiment with the same conditions of circuit in every respect, except that the time of making the circuit alone is different will give entirely different results as before mentioned dependent upon the phase of the E. M. F. at the instant of make.

A number of cases have been calculated from the equations and represented in Figs. 19, 20, 21 and 22. These figures correspond to different times of make or to different values of the angle ψ_1 in the equation. The cases represented in the figures correspond to the values of $\psi_1 = 0°, 45°, 90°$ and $135°$ respectively.

It is seen that the initial value of the logarithmic curve (IV) has a value dependent upon ψ_1. A curve (VI) is shown in the figures to indicate the value of the initial ordinate of the logarithmic curve for all values of ψ_1. This curve is the same in the four figures. Curve circuit I Fig. 27, has been constructed to represent equation (10) below, which when multiplied by the coefficient 0.2435 gives the initial values of the logarithmic curve for different points of the phase.

This curve shows what values of ψ_1 give maximum and minimum values of the logarithmic curves. These are seen to be neither the zero nor the ninety degree values of ψ_1, but the values, 76° 37'.5 for a maximum and 166° 37'.5 for a minimum.

The equation of this curve, circuit I, is from equation (8) seen to be

$$(10) \qquad y = \sqrt{6.4 \sin^2 \psi_1 + 1.61 \sin 2 \psi_1 + 1},$$

which might be written

$$(11) \qquad y = \sqrt{a \sin^2 \psi_1 + b \sin 2 \psi_1 + 1}.$$

Differentating (11) and equating to zero for a maximum, we have the condition that

$$2 a \sin \psi_1 \cos \psi_1 + 2 b \cos 2 \psi_1 = 0,$$

or

$$a \sin 2 \psi_1 + 2 b \cos 2 \psi_1 = 0,$$

or

$$(12) \qquad \tan 2 \psi_1 = - \frac{2 b}{a}.$$

Applying this general condition for maximum or minimum to (10) above, we have

$$\tan 2 \psi_1 = - \frac{2 \times 1.61}{6.4} = - 0.504$$

or

$$\psi_1 = 76° \, 37'.5 \text{ or } 166° \, 37'.5.$$

The maximum and the minimum points are thus 90° apart.

The frequency of the oscillation of the sine wave represented in curve (V.) is determined in equation (7) by the coefficient a whose value is shown in equation (2). This depends upon the

constants of the circuit only, and remains always the same for any circumstances of make for the given circuit. The frequency calculated for this case is 37.5 complete oscillations per second.

Another important question is the phase at which the oscillation within the logarithmic curve begins. This must be known in order to draw the sine curve (V.) in proper position upon which depend curves (II). and (III). This relation is shown in equation (7) to be

$$(13)\ x = 180^\circ + \text{arc-cot} - \left[\frac{2 \cot \psi_1 + RC\omega}{\omega\sqrt{4\,L\,C - R^2\,C^2}}\right],$$

and it too therefor depends upon ψ_1. In the example just given where $\psi_1 = 0$, cot $\psi_1 = \infty^\circ$. Hence the phase was 360° or the same thing 0°. By plotting equation (13) this general relation of the phase for any value of ψ_1 is shown.

To sum up what has been said concerning the equations and figures in this case, the general equation (7) applies to any condition ot circuit or "make." In the case of the particular circuit named the equation reduces to (8) which applies to any circumstance of "break." The four cases represented in Figures 19, 20, 21 and 22 correspond to the four cases of "make" when $\psi_1 = 0$, 45°, 90° and 135° respectively. These curves have four corresponding equations derived from (8) above. These equations are first, equation (9) above which applies to the case $\psi_1 = 0$. The other three equations which have not yet been given are for $\psi_1 = 45^\circ$

$$(14)\quad i = .493 \sin \psi + .587\, \varepsilon^{-189\,(t-t_1)} \sin \left\{ 237\,(t-t_1) + 322^\circ\, 16' \right\},$$

for $\psi_1 = 90^\circ$

$$(15)\quad i = .493 \sin \psi + .662\, \varepsilon^{-189\,(t-t_1)} \sin \left\{ 237\,(t-t_1) + 308^\circ\, 34' \right\},$$

for $\psi_1 = 135^\circ$

$$(16)\quad i = .493 \sin \psi + .400\, \varepsilon^{-189\,(t-t_1)} \sin \left\{ 237\,(t-t_1) + 286^\circ\, 49' \right\}.$$

Referring back to the photographs shown in Figs. 13, 14 and 15, it is seen in each case that the record starts with a very small spot of light, and next follows a very large spot, then a smaller one followed by a larger, until they are finally equalized. Each figure shows two reproductions from the same plate, the small figure placed just below the large one, being the actual size of the record as taken, and the large figure is merely an enlargement from the smaller one. In the process of enlarging, the

figure is reversed so that the enlarged picture reads from right to left and the natural sized one from left to right. These three figures correspond fairly closely to that shown in the drawing, Fig. 20, where it is seen that the resultant wave curve (III.) exhibits the same general succession of waves, as shown in the photograph.

Circuit II.

As representing another distinct case corresponding to a different circuit from that just discussed, a view is shown in Fig. 16 of the result obtained from a circuit the same as that previously described, except that half the number of condensers are used making the capacity 4.78 microfarads.

Referring to equation (7) and substituting the values of the constants for this second case, we obtain the equation

$$(17) \quad i = 0.560 \sin \psi + 0.332 \sqrt{2.68 \sin^2 \psi_1 + 0.805 \sin 2\psi_1 + 1}$$
$$\varepsilon^{-189(t-t_1)} \sin \left\{ 396(t-t_1) + 180^\circ + \text{arc-cot}- \left[\frac{2 \cot \psi_1 + 1.61}{3.38}\right] \right\}$$

which corresponds to (8) above.

Calculating the values of the radical expression for different values of ψ_1, a curve, circuit II, Fig. 27, corresponding to curve circuit I, of the first case is constructed, which when multiplied by the coefficient 0.332 gives the initial values of the logarithmic curve for different points of the phase. The maximum value of the logarithmic curve in this case is 0.654 corresponding to the value 0.680 of case I. The minimum value is 0.292 corresponding to 0.191 of the previous case. These values occur at the angles $\psi_1 = 74^\circ$ for a maximum, and $\psi_1 = 164^\circ$ for a minimum.

The natural frequency of oscillation in the circuit is increased by using three condensers instead of six, to sixty-three complete oscillations per second corresponding to the period 0.01586 of a second.

The four cases corresponding to the values of $\psi_1 = 0^\circ$, 45° 90° and 135° respectively, are shown in Figures 23, 24, 25 and 26. These are represented by the equations,

(18) For $\psi_1 = 0$

$$i = 0.560 \sin \psi + 0.332\, \varepsilon^{-189(t-t_1)} \sin \left\{ 396\,(t-t_1). \right\}.$$

(19) For $\psi_1 = 45^\circ$

$$i = 0.560 \sin \psi + 0.588\, \varepsilon^{-189(t-t_1)} \sin \left\{ 396\,(t-t_1) + 317^\circ\, 9' \right\}.$$

(20) For $\psi_1 = 90^\circ$

$$i = 0.560 \sin \psi + 0.637\, \varepsilon^{-189(t-t_1)} \sin \left\{ 396\,(t-t_1) + 295^\circ\, 28' \right\}.$$

(21) For $\psi_1 = 135°$

$$i = 0.560 \sin \psi + 0.411\, \varepsilon^{-189\,(t-t_1)} \sin \left\{ 396\,(t-t_1) + 263°\,22' \right\}.$$

It is seen that the photograph, Fig. 16, which is a chronograph record using this circuit, has first, beginning on the right of the enlarged view and on the left of the natural sized one, a small spot and then a second a little smaller, and the third larger than the average and the rest about the average. This corresponds well with the drawing, Fig. 24, and to equation (19) where $\psi_1 = 45°$.

Figs. 17 and 18 are taken with the same circuit as above, except that the condensers were entirely removed from the circuit. Here the enlarged view and the natural sized one are each read from the same side, namely the left hand side. The first wave alone appears larger than the normal, and they then become uniform.

This also corresponds exactly with what is expected theoretically. There is this difference however between the cases, which is interesting to note. There is no oscillation of the current at the "make," but simply a gradual change according to the logarithmic curve. The interesting feature is that this logarithmic curve may have a zero value for a certain value of ψ_1, while the circuits containing condensers have only minimum values.

IV. CONCLUSION.

In closing this paper, which in the sense that a chronograph based upon this new principle has now been constructed, installed and tested in actual practice, naturally marks a distinct step in its progress, we cannot refrain from submitting a few observations both upon its future field of usefulness as a military instrument of precision, and also some of a more general character which have been specially emphasized during the progress of the experiments. The experiments thus far recorded have necessarily been of a disconnected and superficial character both on account of being always obliged to subordinate this work to other regular routine duties which have been exacting, and because it has been impossible to be together for but very brief periods at wide intervals apart. This accounts in part for lack of consecutiveness and systematic thoroughness of treatment, which is much to be desired in physical research. But in using the small time thus far available, the object has been rather to indicate the range of application of this new instrument than to exhaustively treat any one application, in the hope that in the interest of science others having more time and facilities than ourselves

may possibly be induced to work with it and to themselves discover new fields for its use.

Gunnery Problems.

From one point of view it may perhaps be said that the greatest difficulty which the ordnance engineer has to contend with is that he is required to design, and construct for a class of phenomena distinct in themselves, which are so rapid in their action and effects that all ordinary methods and tests of material cannot be relied upon for safe constructions without uncertain and undetermined factors of safety. Where the bridge engineer is supplied with accurate data the ordnance engineer is involved in more or less theoretical hypotheses. At this time not only is the actual amount of pressure developed in a gun undetermined but the progressive effects of this pressure upon the various tubes and hoops of a built-up gun is also a mooted question.

The reason for this, it is needless to mention, is that, since there is no blow however sudden but which is progressive in its action, reliable experimental data are not obtainable, because the unit of time which can be reliably and consecutively recorded and measured is too great for the class of phenomena involved. It seems then that throughout ballistic experiments from the motion of the projectile to even the behavior of the carriage under fire, the *one essential* element where the greatest error should occur in the data is in the measurement of the time.

The Unit of Time.

From a physical point of view it may be remarked that the time unit unlike the units of length or mass is in a sense a derived unit. Unlike the standard meter or gramme which can be directly examined, compared and copied, we can have no direct model of a second, but must *derive* the unit second by observations upon the motion of some standard body such as a pendulum or the earth. This process of observing the motion of the standard body involves the recording of the exact instant between two or more points of the motion of the body which successively repeat themselves. Ultimately then, where we are concerned with very minute intervals of time, the reliability of the method depends largely upon the ability to produce a record of the phenomena at a distance as nearly simultaneously with the occurrence of the phenomena itself as possible. Divested of details it may be said that the *essential point* of this chronograph whereby it is thought a distinct advance is made is, that it places the reliable measure-

ment of minute intervals of time upon a new basis and opens up in consequence a range of experiment hitherto closed.

Exterior Velocities.

Although not yet actually accomplished with guns of larger caliber for lack of opportunity, yet there is no reason to doubt that ordinary exterior velocities can now be taken within a few feet of any of our modern guns regularly mounted in barbette or upon disappearing carriages. This will permit measurements, which have heretofore been limited to a proving ground on account of the great height and distance of ballistic screens which would be necessary in front of a modern parapet, to be taken directly upon the parapet at any fort and at any time in connection with the regular gun practice.

Although the blast of a modern high-power gun is terrific in force, yet when the prepared points can be as near together as is desired, the problem is at once shifted from the chronograph itself to the distant gun where it becomes a matter of constructing such a metal screen frame as is found necessary by trial to withstand the blast, being always assured that whatever the projectile causes to happen in the transmitter circuit will be found faithfully and accurately recorded upon the receiver of the instrument. For instance there is no reason, if it is found necessary, why a steel screen frame a few feet in length sufficient to bear three or four small ballistic screens could not be constructed and made attachable to a permanent bed plate foundation upon the parapet itself, or better than this that a distance of four or five feet of the length of the bore of the gun at the muzzle, be permanently prepared during fabrication with perforations such as Nobel and Able employed to be used for taking velocities whenever desired. This would not materially impair the efficiency of the gun, and since the interruptions in the transmitter circuit would then always occur at the same carefully prepared points, not only would the calculations be abridged but the transmitter circuit would be complete by attaching flexible wires to permanent binding posts upon the side of the gun chase.

Furthermore since it has been shown in the case of the 3."2 field rifle* that the velocity of the projectile from the muzzle of the gun to a considerable distance along the trajectory passes through a maximum value, it seems that the meaning of "initial velocity" should be more carefully defined, especially as the

* Experiments with a new Polarizing Photo-Chronograph. *Journal of the U. S. Artillery*, Vol. IV, No. 3.

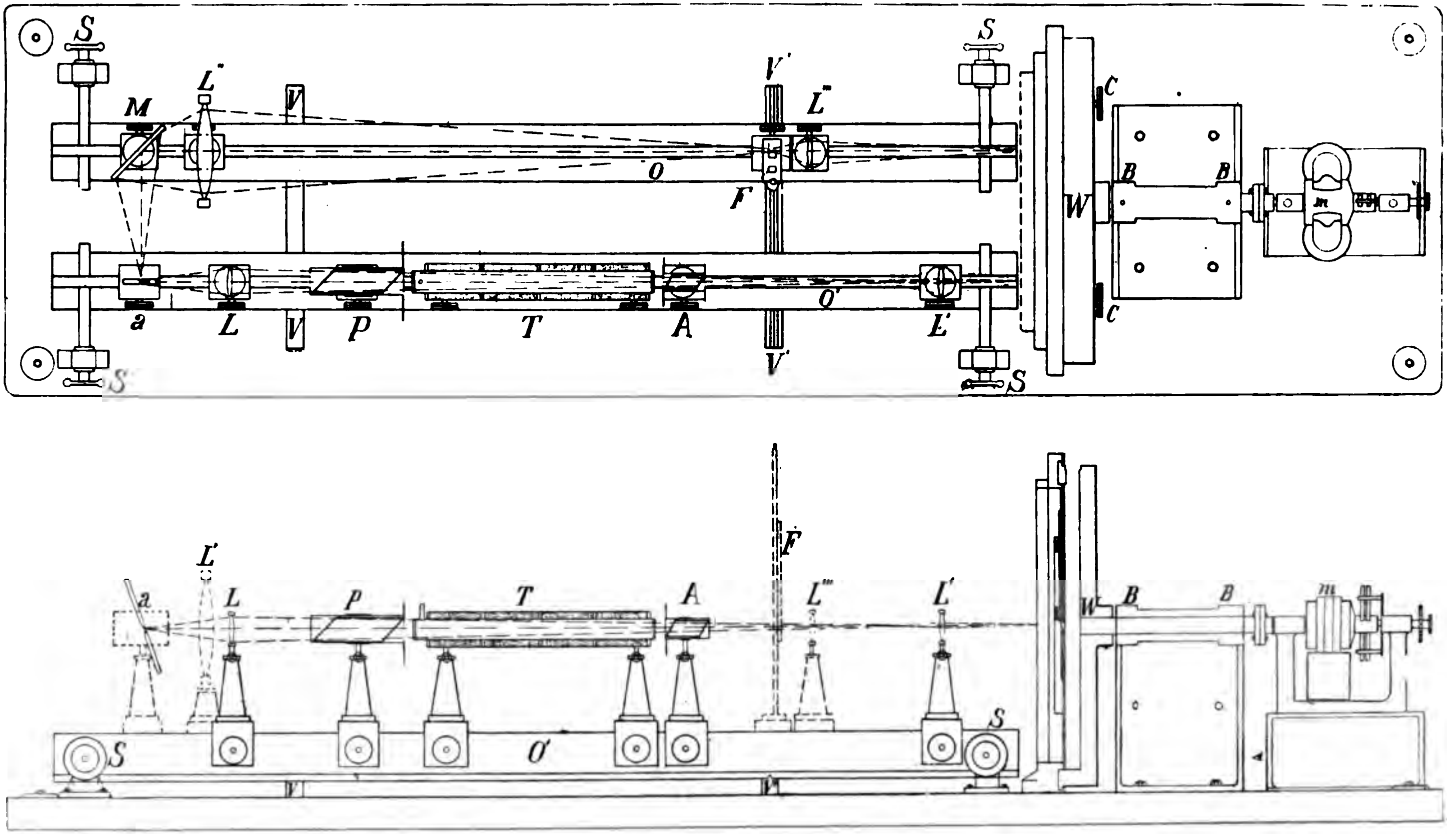


FIGURE 1.

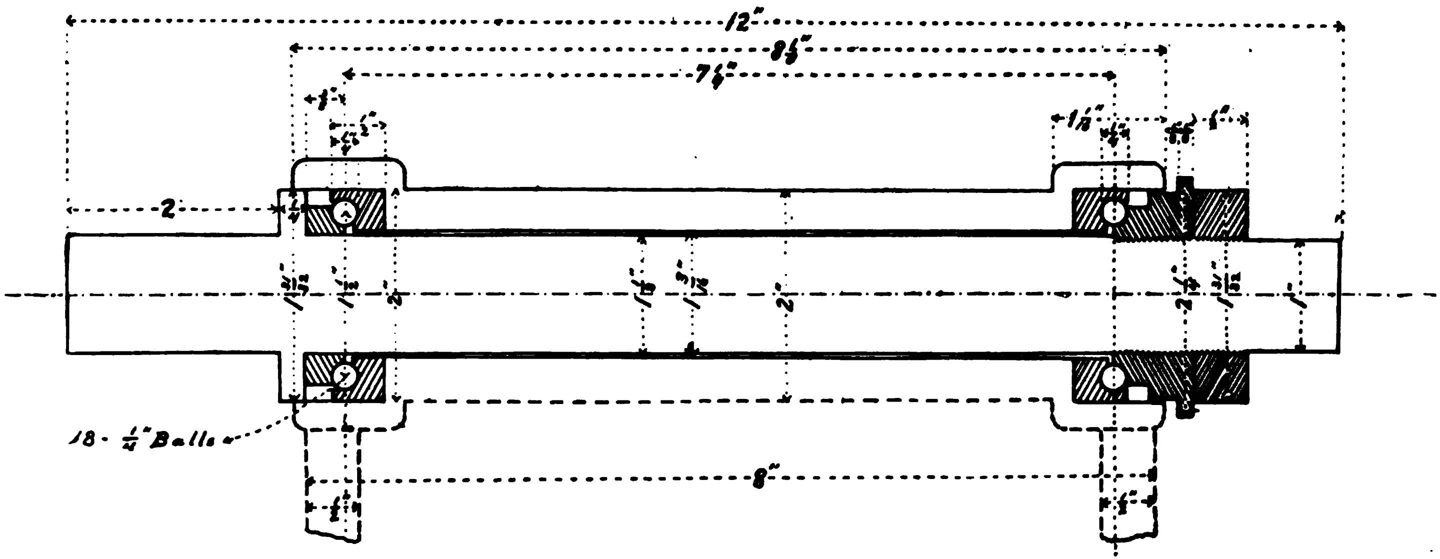


FIGURE 4.
Details of Shaft and Bearings for Camera Wheel.

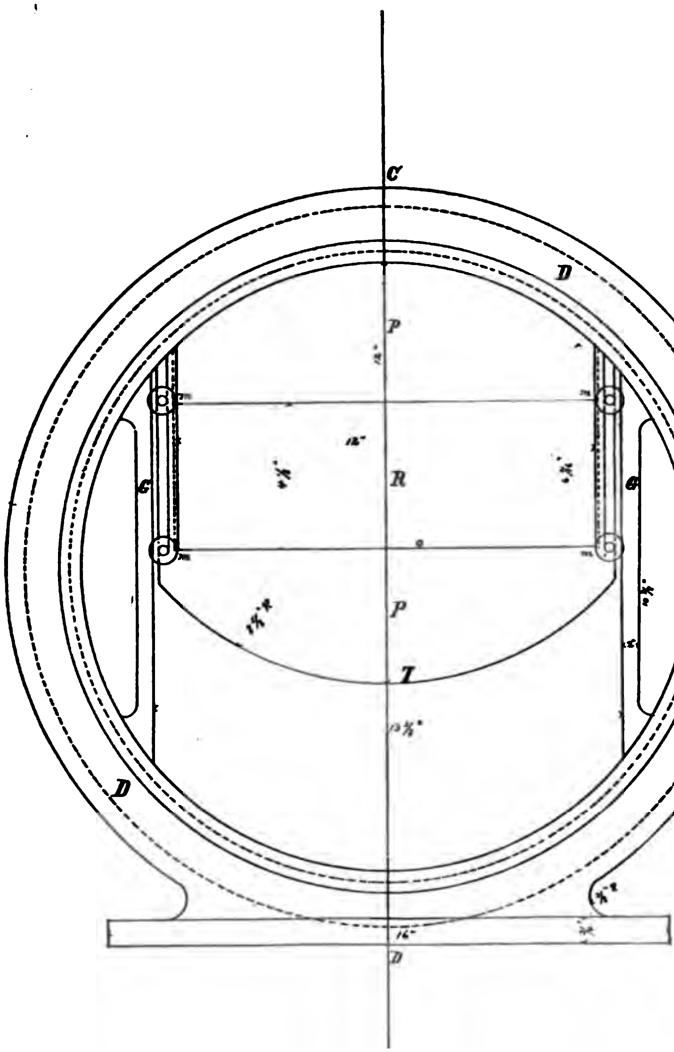


FIGURE 5.
Front Elevation of Dark Chamber.

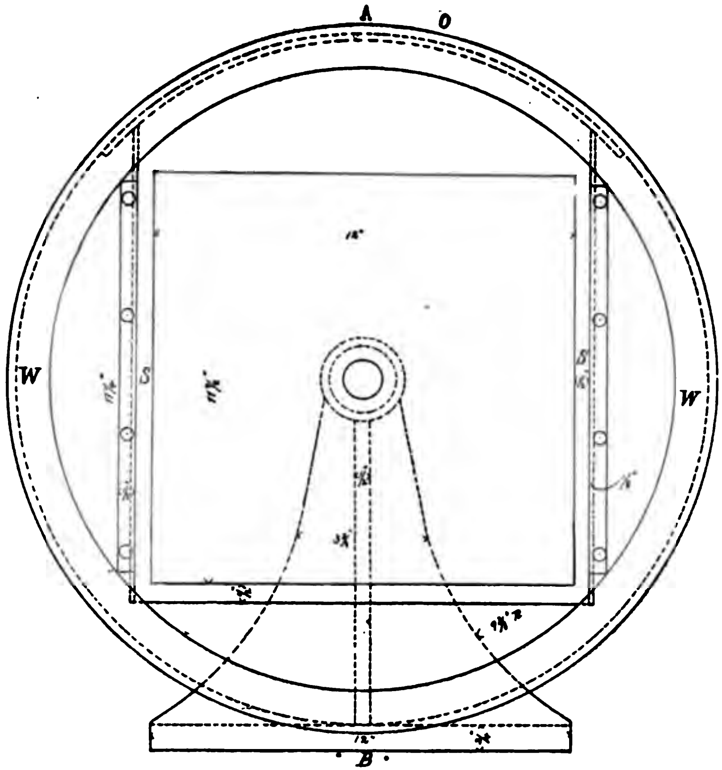


FIGURE 7.
Front Elevation of Camera Wheel.

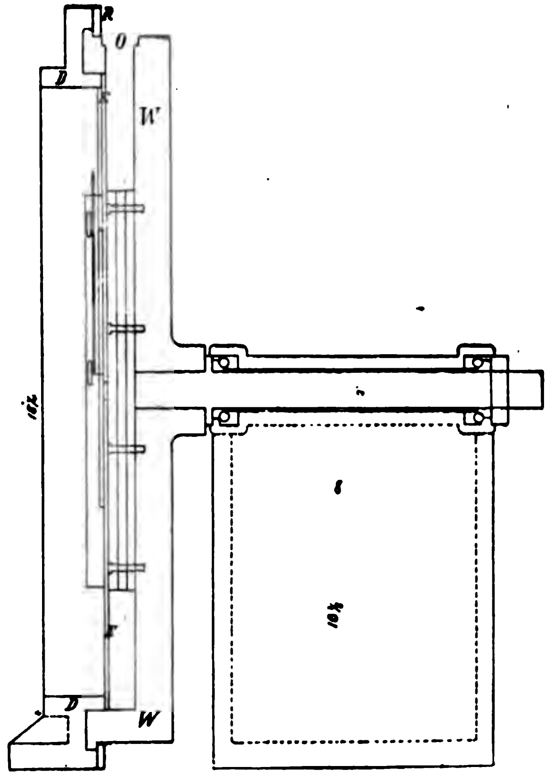


FIGURE 6.
Vertical Section through Camera Wheel and Shaft.

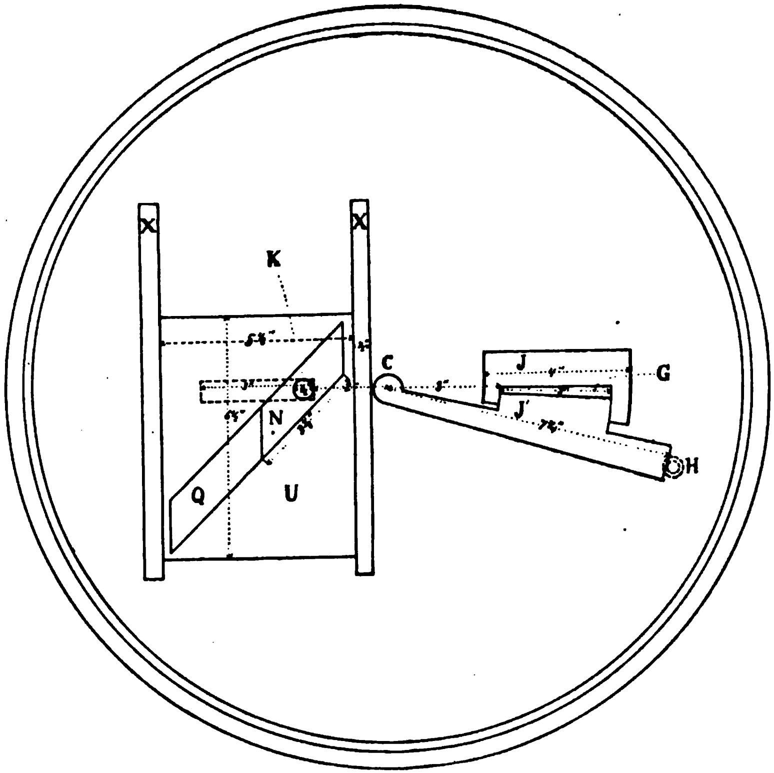


FIGURE 8.
Details of radial Slit and Fork Exposure.

FIGURE 10.

COMBINED CHRONOGRAPH AND FORK RECORDS.

Tuning Fork 250 (single) vibrations per second.

Actual size of plate 12″ × 12″

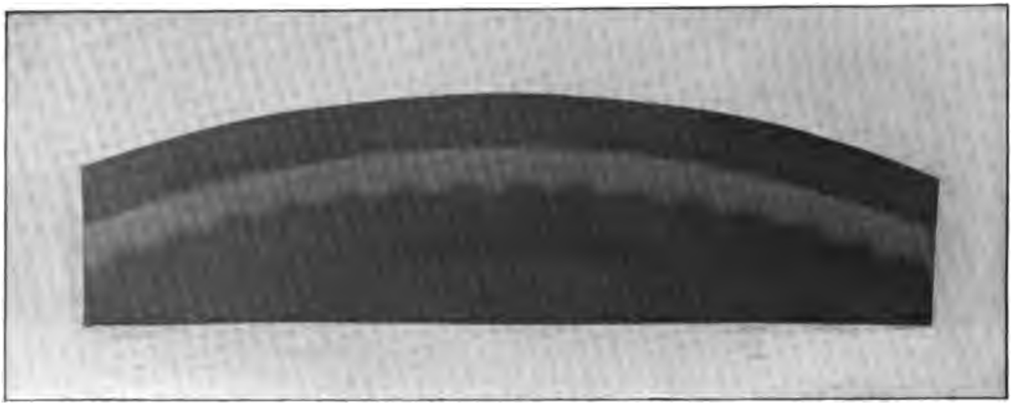


FIGURE 11.

PART OF ACTUAL VELOCITY RECORD, 3''.2 FIELD RIFLE BY "COMBINATION" METHOD.

Tuning Fork 500 (single) vibrations per second.

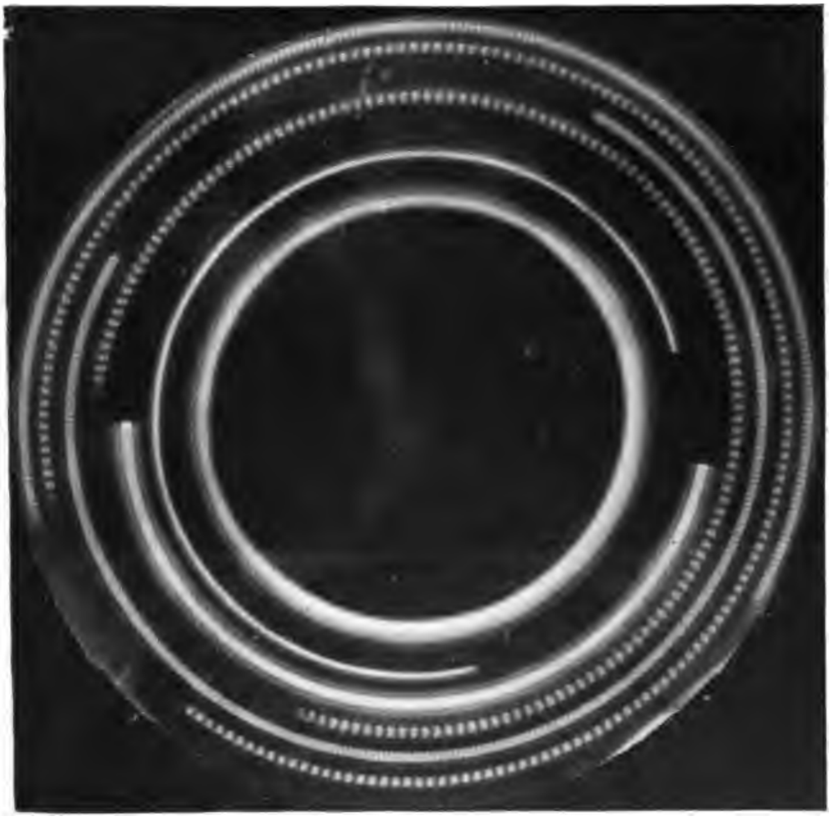


FIGURE 12.

CHRONOGRAPH RECORDS OF THE ALTERNATING CURRENT UNDER VARYING CONDITIONS OF CIRCUIT AND SPEED OF PLATE.

Actual size 12″×12″

ALTERNATING CURRENTS AT "MAKE" FOR AN HARMONIC E. M. F.

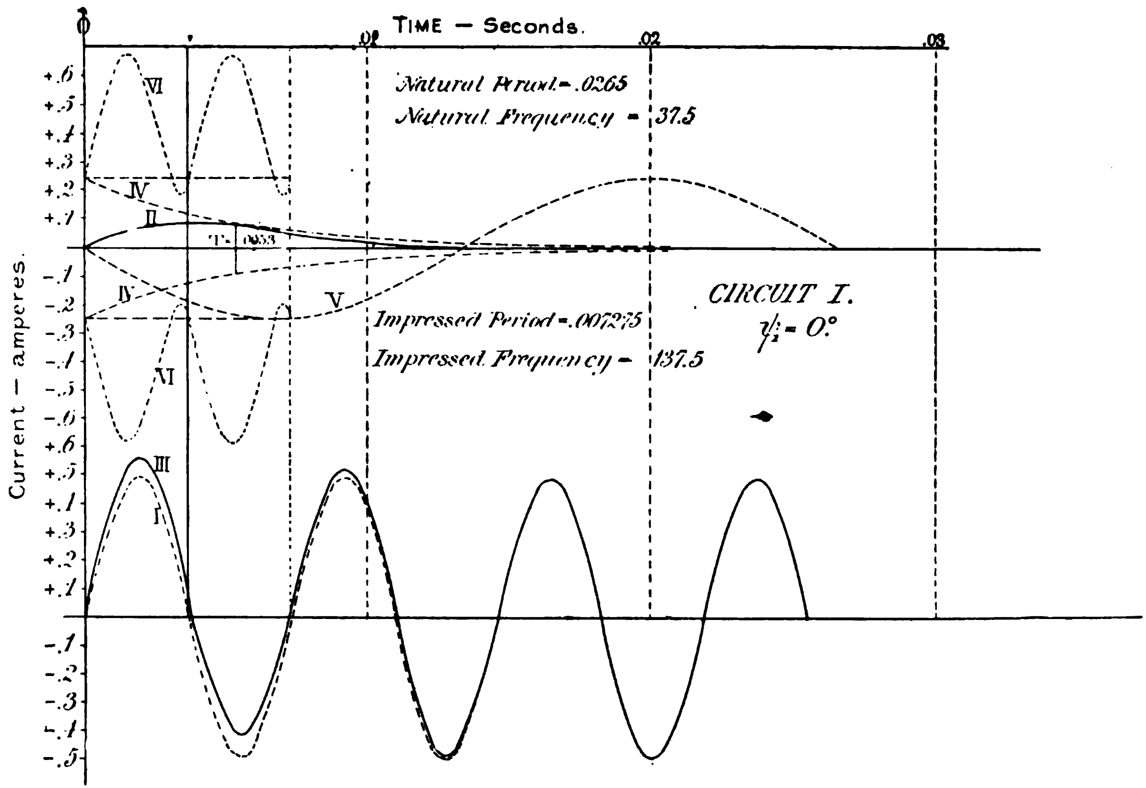
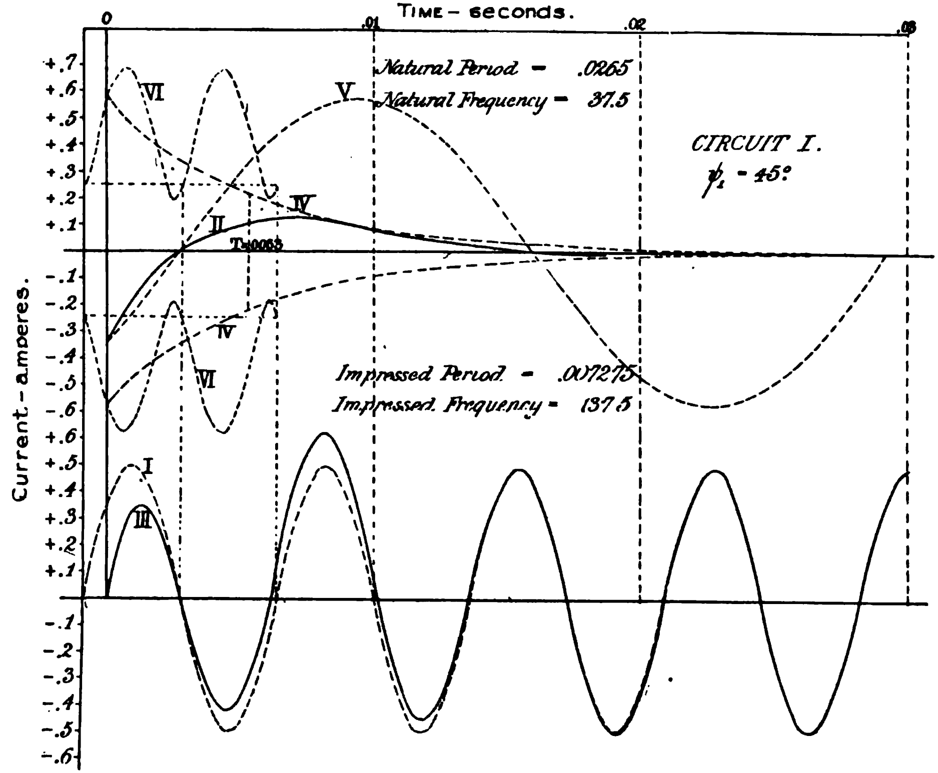


Figure 19.

Curve III. shows the Current which flows after the Introduction of an Harmonic E. M. F. into a circuit with *R*, *L*, and *C*. It is the Sum of the two Component Curves, I. a Sine-curve, and II. a Sine-curve with an Amplitude decreasing according to a Logarithmic Decrement.



Time – seconds.
0
.01
.02
.03
Current – amperes.
Natural Period = .0265
Natural Frequency = 37.5
CIRCUIT I.
ψ_1 = 45°
Impressed Period = .007275
Impressed Frequency = 137.5
T = .0063
I
II
III
IV
V
VI

FIGURE 20.

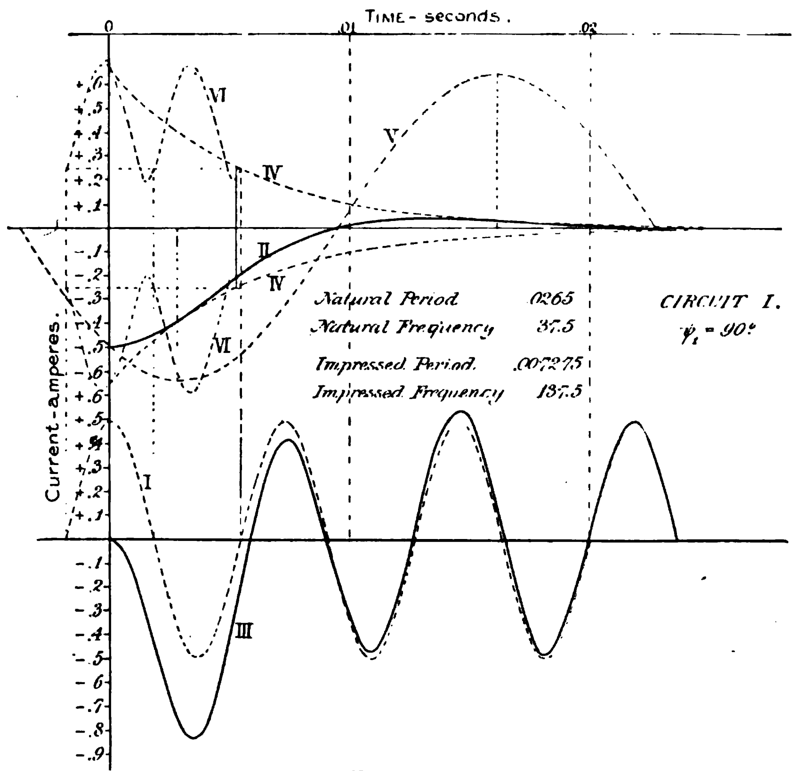

TIME - seconds.
0
.01
.02
Current-amperes.
Natural Period .0265
Natural Frequency 37.5
Impressed Period .007275
Impressed Frequency 137.5
CIRCUIT I.
$\psi_1 = 90°$
I
II
III
IV
V
VI

FIGURE 21.

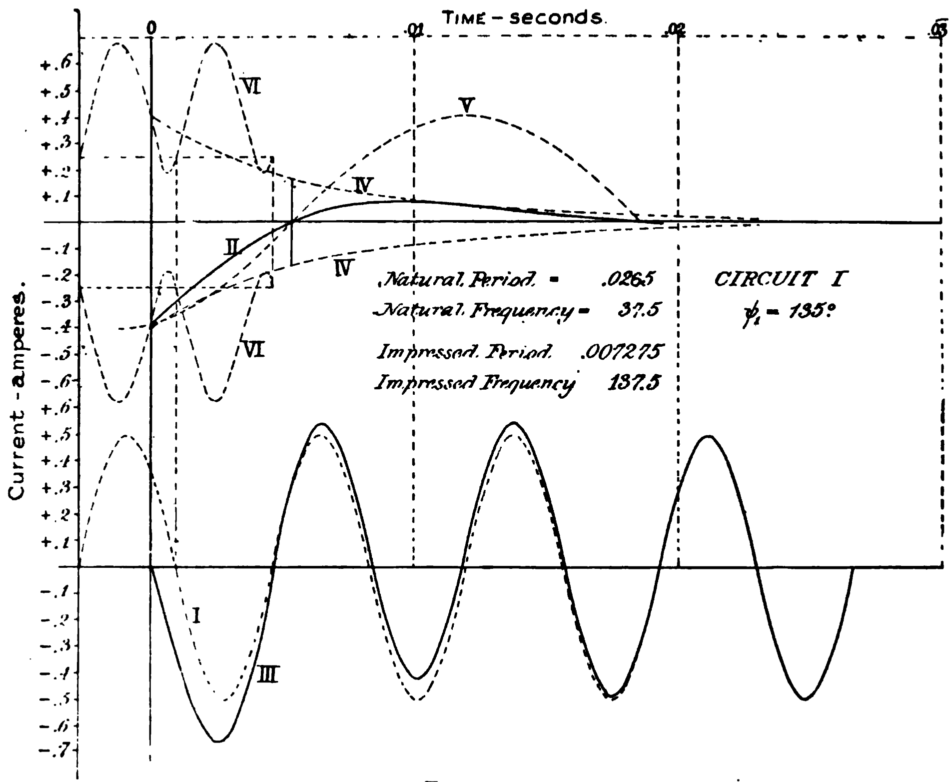

TIME - seconds.
0
.01
.02
.03
Current - amperes.
+.6
+.5
+.4
+.3
+.2
+.1
-.1
-.2
-.3
-.4
-.5
-.6
-.7
I
II
III
IV
V
VI
Natural Period = .0265
Natural Frequency = 37.5
Impressed Period .007275
Impressed Frequency 137.5
CIRCUIT I
$\phi_1 = 135°$

FIGURE 22.

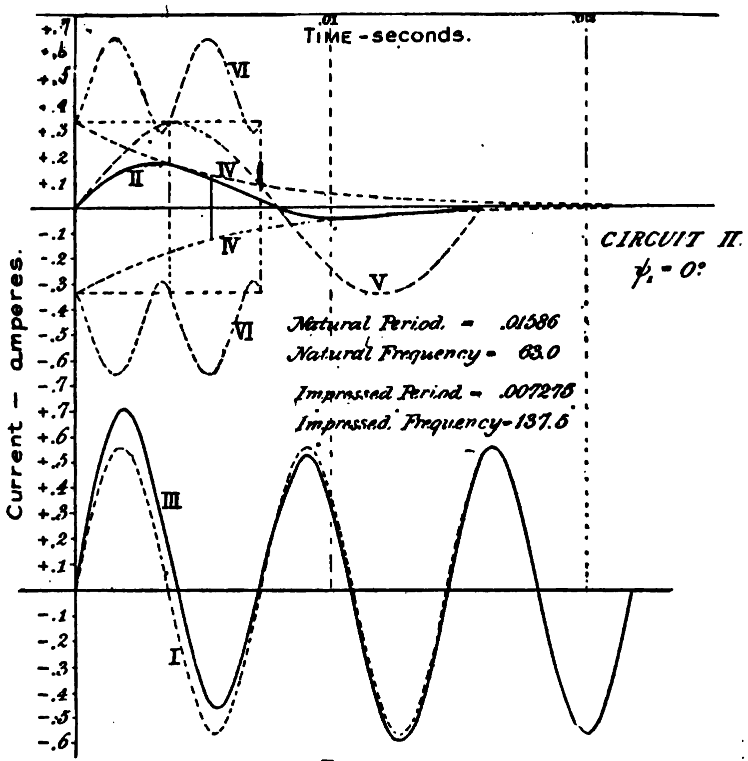

TIME - seconds.
.01
Current — amperes.
+.7
+.6
+.5
+.4
+.3
+.2
+.1
-.1
-.2
-.3
-.4
-.5
-.6
-.7
I
II
III
IV
V
VI
CIRCUIT II.
$\psi_1 = 0°$
Natural Period. = .01586
Natural Frequency = 63.0
Impressed Period = .007276
Impressed Frequency = 137.5

FIGURE 23.

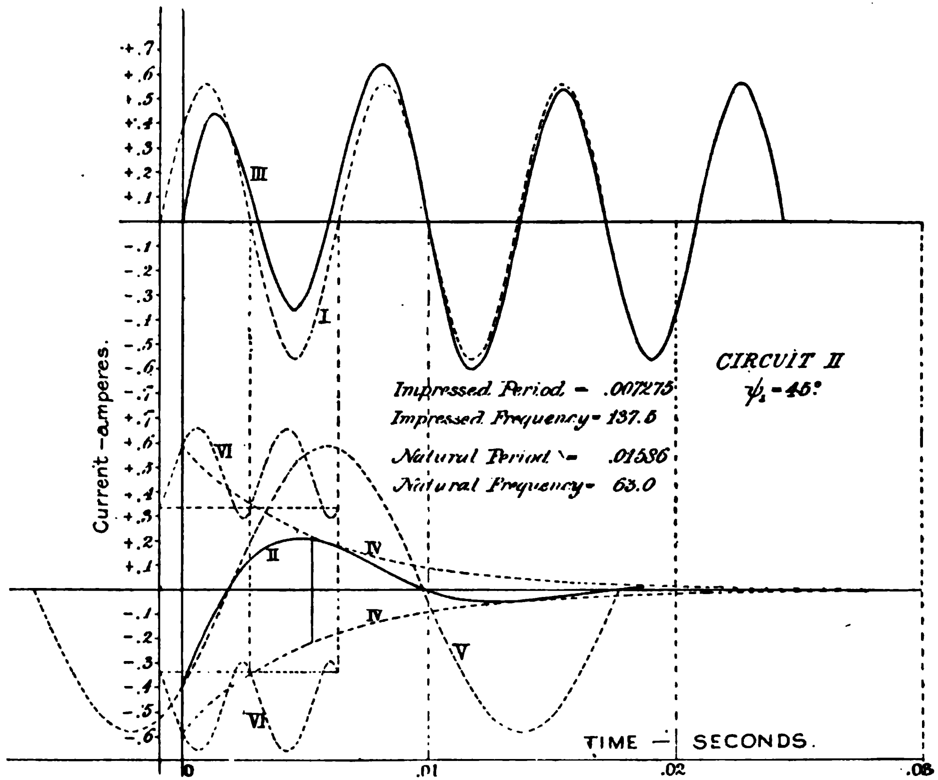

CIRCUIT II
$\psi_1 = 45°$
Impressed Period = .007275
Impressed Frequency = 137.5
Natural Period = .01586
Natural Frequency = 63.0
Current – amperes.
TIME — SECONDS.
I
II
III
IV
V
VI
0
.01
.02
.03

FIGURE 24.

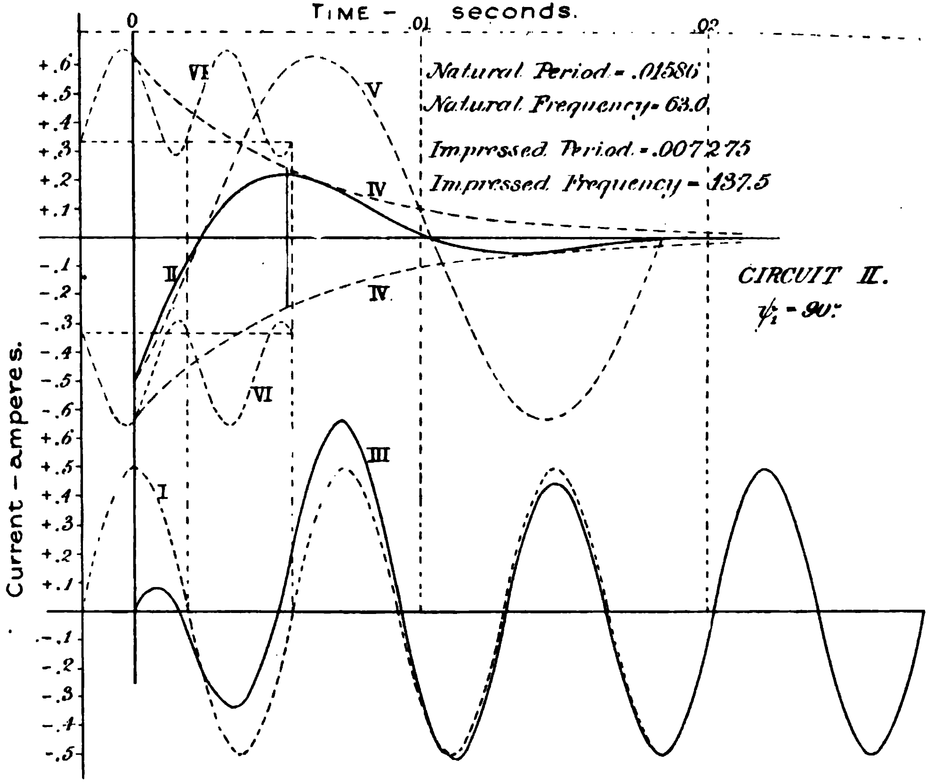

TIME - seconds.
0
.01
.02
Natural Period = .01586
Natural Frequency = 63.0
Impressed Period = .007275
Impressed Frequency = 137.5
CIRCUIT II.
$\psi_1 = 90°$
Current - amperes.
I
II
III
IV
V
VI

FIGURE 25.

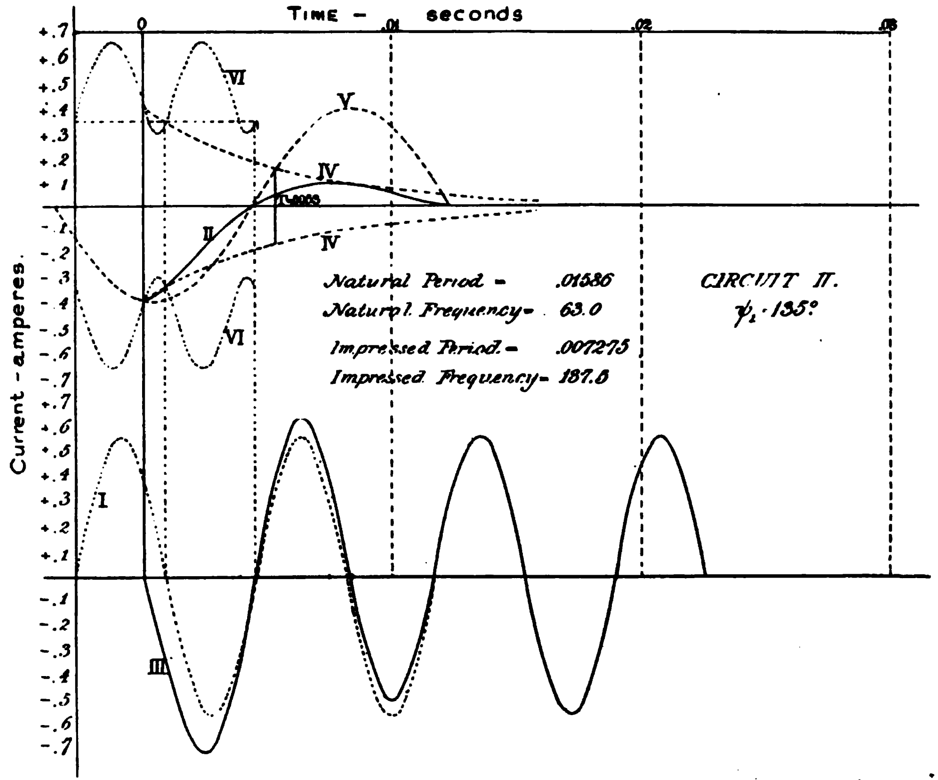

TIME - seconds
0
.01
.02
.03
Current - amperes.
+.7
+.6
+.5
+.4
+.3
+.2
+.1
-.1
-.2
-.3
-.4
-.5
-.6
-.7
I
II
III
IV
V
VI
Natural Period = .01586
Natural Frequency = 63.0
Impressed Period = .007275
Impressed Frequency = 137.5
CIRCUIT II.
$\psi_1 \cdot 135°$

FIGURE 26.

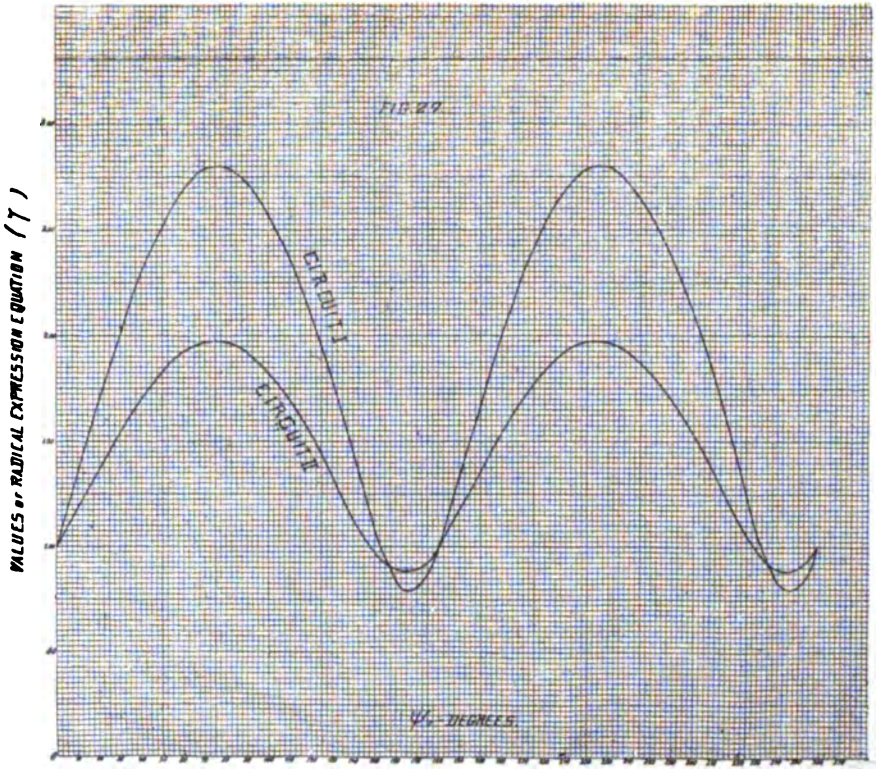


FIG 27
CIRCUIT I
CIRCUIT II
VALUES OF RADICAL EXPRESSION EQUATION (T)
ψ_0 - DEGREES

FIGURE 27.

acceptance or rejection of a lot of powder from the manufacturer sometimes depends upon a very few feet more or less of initial velocity shown under test.

Interior Velocities, etc.

Opportunity has not yet been presented for further experiments with larger guns upon the motion of projectiles inside the bore of the gun, a subject the importance of which is unquestioned, since the chronograph at the Artillery School is the only one as yet installed.

As stated above the problem to be attacked for these guns is now at the gun and not at the chronograph, and it is hoped that this work can soon be seriously taken up at a proving ground where facilities for systematic and continuous work are available.

It may be remarked that projectile velocities are greater than those of any other body propelled by engines made by man, and the direct experimental study of their motion is, in consequence, correspondingly difficult. To obtain observations such as have already been given in a previous paper upon experiments inside the bore of the 3.″2 field gun, it was necessary to deal with a unit of time which bears about the same relation to a second as a second does to a third of an hour. In the case of the study of the recoil of gun carriages or the motion of pistons in hydraulic cylinders in general, the velocities being inversely as the masses, these motions are then so slow when compared with that of the projectile, that they should easily yield to a thorough experimental treatment.

Furthermore if the motion of a projectile through the bore can be determined by a direct dynamic method, a gun would seem a good physical apparatus with which to study the laws of the thermodynamics of gases under adiabatic expansion.

A Laboratory Apparatus.

The brief account given in this paper of the application of this chronograph to the study of purely physical problems in the laboratory indicates, it is thought, its usefulness in this field. The rapid advance which alternating currents and alternating current machinery have made in the industrial world has led to a thorough theoretical study of the subject, but the experimental verifications have been attended with difficulty on account of the very rapid changes in current which must be continuously followed and recorded even with the lowest commercial frequencies. This difficulty is multiplied many times when, as in the

experiments above, it is attempted to follow what happens during the very short interval after the "make" of an alternating current in a circuit containing varying conditions as to resistance, inductance, and capacity.

The design of a chronograph based upon this principle for general physical laboratory purposes, would probably differ in some respects from the one described in this paper, and possess attachments and adjustments not provided for in this instrument, but when carefully considered from this point of view, it is thought that this chronograph would prove a most useful apparatus in the equipment of a physical laboratory.

NOTES ON EUROPEAN SEA-COAST FORTICATIONS.

Translated and compiled from the French: *La Défense des Côtes D'Europe, par Carl Didelot.*

RUSSIA.

Russia is an essentially military power, but Nature seems to have refused her any maritime supremacy. The four seas that wash her shores in Europe are alike closed or controlled by other nations, and can offer no exit for fleets of war. The White Sea is covered by ice almost the whole year; the Baltic is commanded by the Sound and the Great and Little Belts, covered by the guns of Sweden and Denmark; the Black Sea, by a double strait, the Bosphorus and the Dardanelles, situated under the cross fire of Turkish guns. Finally the Caspian is only a lake. Hence results the imperative necessity for Russia to extend her frontiers, either in Asia or in Europe, in order to find a high sea open to her commerce and to her ships. Hence the occupation of the basin of the Amour, which opens to the Russian marine the immensity of the great Pacific Ocean. Hence the repeated attempts on Sweden whose alliance or hostility can open or close the Baltic. Hence, finally, the periodical dismemberment of Turkey, and the slow but uninterrupted march towards Constantinople. Conquest is for Russia, notwithstanding her huge proportions, a geographical necessity, an imperative and fatal law (Lavallée, military geography). In all probability Russia will profit by the first war to seize Swedish Lapland which she has long coveted, and which will afford her on the Atlantic ocean, that is to say on a high sea, excellent harbors that, thanks to the Gulf stream, never freeze over.

(*a*) *Organization.*—The navy has charge of the sea-coast defense. The coast is divided into a certain number of districts dependent on certain ports as headquarters, called ports of the first or second class. The ports of the first class, five in number, are: Kronstadt and Nicolaief, commanded by vice-admirals; Petersbourg, Sebastopol and Vladivostock, commanded by rear-admirals. There are seven ports of the second class, namely: Revel and Bakou, rear-admirals in command; Sveaborg and Batoum, Arkangel, Nicolaiefsk (Amour), and Kagala (Oxus), captains in the navy in command (*Capitaines de vaisseau et capitaines de frégate*).

The submarine defenses have been recently modified by the reorganization of the marines for the torpedo service. Henceforth there will be eight companies of these marines attached to fortresses. Those of Kronstadt, Sveaborg and Sebastopol have 200 men each, the others 100 men each. Formerly there were only two, one at Petersbourg, one at Odessa.

(*b*) Artillery and coast defenses:

The coast artillery includes guns of many calibers. The best pieces or those most used are given in the following table:

Designation of piece.	Model.	Caliber. cm.	Weight.		I. V. f. s.
			Gun in tons.	Projectile in pounds.	
Oboukhoff breech-loading cannon, steel.	new	35.5 (13″.8)	—	1140	1544
	old	35.5	58.5	953	1583
	new	28 (11″)	28.7	561	1802
	old	28	28.7	515	1767
	new	23 (9″)	18	277	1782
	old	23	15.3	248	1739
	—	21.5 (8″.4)	7.3	183	1474
	—	20.3 (8″)	8.9	172	1579
	—	15.3 (6″)	4.4	95	1587
Oboukhoff breech-loading howitzer.	new	28 (11″)	—	598	—
	old	28	8.8	548	940
	—	23 (9″)	5.5	277	1131

These pieces of steel, rifles and hooped, made at Oboukhoff are mounted on hydraulic (glycerine) carriages. Trials have been made of a rifled mortar, caliber 30 cm. (11″.7), the results of which have been very satisfactory.

"The question now is whether to construct guns of cast iron, with steel tubes, to diminish the expense that the arming of all the coast batteries with the costly *steel* material would cause. A recent paper notices the appearance of a gun of this model, caliber 35.6 cm. (66 tons) on one of the works at Kronstadt. * * * Here we see Russia reverting from steel to cast iron, * * * through economical reasons." (Degouy, *Opérations combinées.*)

The Russian technical committees have not approved of cupolas. The turrets which arm the forts at Kronstadt are uncovered, and the pieces mounted therein, in general of 27.5 cm. (10″.7) caliber, fire in barbette. The larger part of the sea-coast defenses are of granite, especially those of old construction. The more important forts are armored.

(*c*) Special considerations:

SVEABORG.—The fortress of Sveaborg has long been considered

a masterpiece of military architecture and the Gibraltar of the Baltic. With its adjacent works, it occupies seven islands which dot the harbor to the southeast of Helsingfors. No less than four lines of fortifications are cut in the granite of the isle of Gustafsvoern (sword of Gustave), the key of the position. Emperor Nicholas has doubled the strength of this place by connecting it to Helsingfors by a covered way of powerful batteries.

The defenses consist of: Fort Braberg, Fort Ulricasborg; the batteries on the isles of Bucsholm and Sandholm, about 15 pieces; eight batteries of solid earth, open at the gorge, mounting about 60 guns, south of Helsingfors.

Nicholas Battery, 18 guns; the fortress of Sveaborg itself, the most important and best armed of all. The works on Bak-Holmen: a battery of 12 pieces commanding the pass of Gustafsund, a small fort and three batteries of 22 guns defending the approaches thereto.

The batteries on Hungs-Holmen and on Sandhamn, commanding the harbor of Miölö, and preventing a disembarkment on the isle of Sandhamn.

Sveaborg is undoubtedly of exceptional strength, but of more importance is Kronstadt, the seat of the Admiralty and where the principal elements of the maritime strength of the Empire are concentrated.

KRONSTADT.—The port is defended by a formidable line of defense, which could protect the whole Russian fleet and bar the entrance of the port to an enemy wishing to approach St. Petersbourg. This line of defense, 29 km. (18 miles) long, comprises 30 works, of which 14 are on the land, 7 to the north and 9 to the south; it leaves the southern shore (Oranienbaum), cuts the southern harbor, Kotline island, the northern harbor and ends on the coast of Finland. The works exposed directly to fire are in a great measure armored, and the others are built of granite or of earth. The southern roadstead is defended by several lines of forts, the first of which is armed with 88 guns of 11″ and 14″ caliber; 100 other guns on Kotline island can also be brought to bear on the defense of this channel. Two hundred guns bear upon the northern roadstead. Kotline island is protected on the west side by four lines of forts. Finally, numerous submarine mines, submerged in the channels, and permanently along the coasts, lend their important aid in the defense of this great Russian military port.

Among the forts of the defense, may be mentioned:

Fort No. 3 or Milioutino. This work has six armored turrets

each containing one gun, caliber 27.5 cm. (10″.8). It has, besides, 10 pieces on the ramparts.

Fort No. 4 or Fort Constantin: casemated, and mounts 25 guns of large caliber, divided among five armored batteries. This armor consists of four wrought iron plates, total thickness of 425 mm., supported by a teak backing 90 cm. thick. The fort is surmounted by a turret which carries two guns, 27.5 cm. caliber, placed at opposite ends of the same diameter. The disadvantages of barbette fire have been minimized by providing the guns with mechanisms that permit their being lowered behind the parapet for loading.

Of the forts of the interior line of defense, there are:

Fort Paul I.: a large granite tower, two tiers of casemates, 60 guns. It has on its upper platform six armored turrets, 35 cm. thick, each armed with one gun, 27.5 cm. caliber.

Fort Alexander I.: same as the preceding, but with four tiers of casemates and 116 guns.

The other remaining forts are all casemated, mounting many guns of large caliber.

Finally, at the extremity of Kotline island, we find one gun of 110 tons, 15.8 m. long, which throws a projectile weighing 1450 pounds.

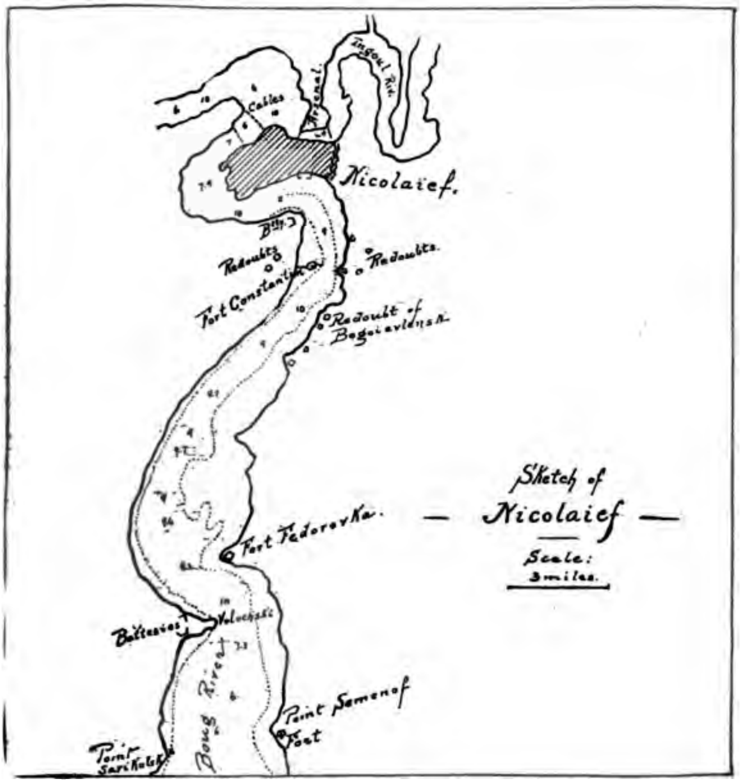
All the works are connected by submarine or underground cables.

About five versts to the northeast of Libau, the military port of Treuliebshof is just being constructed. The end in view is to have, in the Baltic, a place of refuge for the Russian fleet always accessible, and more convenient to reach or to leave than Sveaborg or Kronstadt. Libau being very near the German frontier, the strategic importance of the new port will be very great. In 1890, 13,000,000 roubles were appropriated to create there in five years, if not a complete arsenal, at least a port of sure refuge for the fleet.*

Nicolaief, on the left bank of the Boug, is the great military port of Russia on the Black Sea. Strong in itself, on account of its situation, it has, besides, received numerous works for its defense. About thirteen batteries (redoubts and coast batteries) have been built along the banks of the river. They are of earth.

Sebastopol, was dismantled in 1855, but the Russians are actively working to reconstruct its defenses and to rearm them. The maritime forts still existing are armed, as well as many coast

* This new harbor, Emperor Alexander III, at Libau, is now engaging the attention of the military press; see *Revue Maritime*, April; *Mittheilungen aus dem Gebiete des Seewesens*, No. 8.



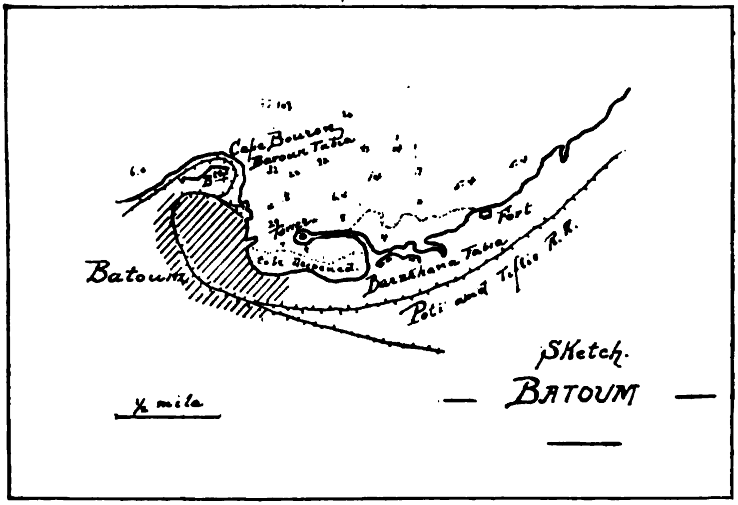
batteries constructed during the Turko-Russian war; many works are in course of construction, some only projected. Those works that have been remodeled and renovated or completed will soon assume a satisfactory condition. None will be armored, but the natural advantages due to their command will be made use of.

Batoum.—Except Fort Saint Nicolas, at the mouth of the Cholok, there is nothing to make mention of until Batoum is reached. This important city, at the end of the bay, is a base of operations, and refitting station for the Russian fleet of the Black Sea. The defenses of the place are not yet completed, but are already far advanced and are of considerable importance. They consist of:

The Bouroun-Tabia and Barzkhana-Tabia batteries, two enormous works of cut stone, casemated.

A fort situated on the east side of the bay, and numerous batteries on the heights about Kakhabéri, armed with Krupp's 60-ton guns.

A powerful battery overlooking the sea about six miles from Batoum, at the mouth of one of the longest tunnels of the Caucasus.



At all the Russian ports on the Black and Baltic seas, the submarine defense is assured by lines of torpedoes, the number varying from two to four. The first is about 3,400 m. (3,683 yards) from the forts, the second from 100 m. to 200 m. beyond that, the third and fourth at the same distance. Generally, fifteen torpedoes are put on one circuit.

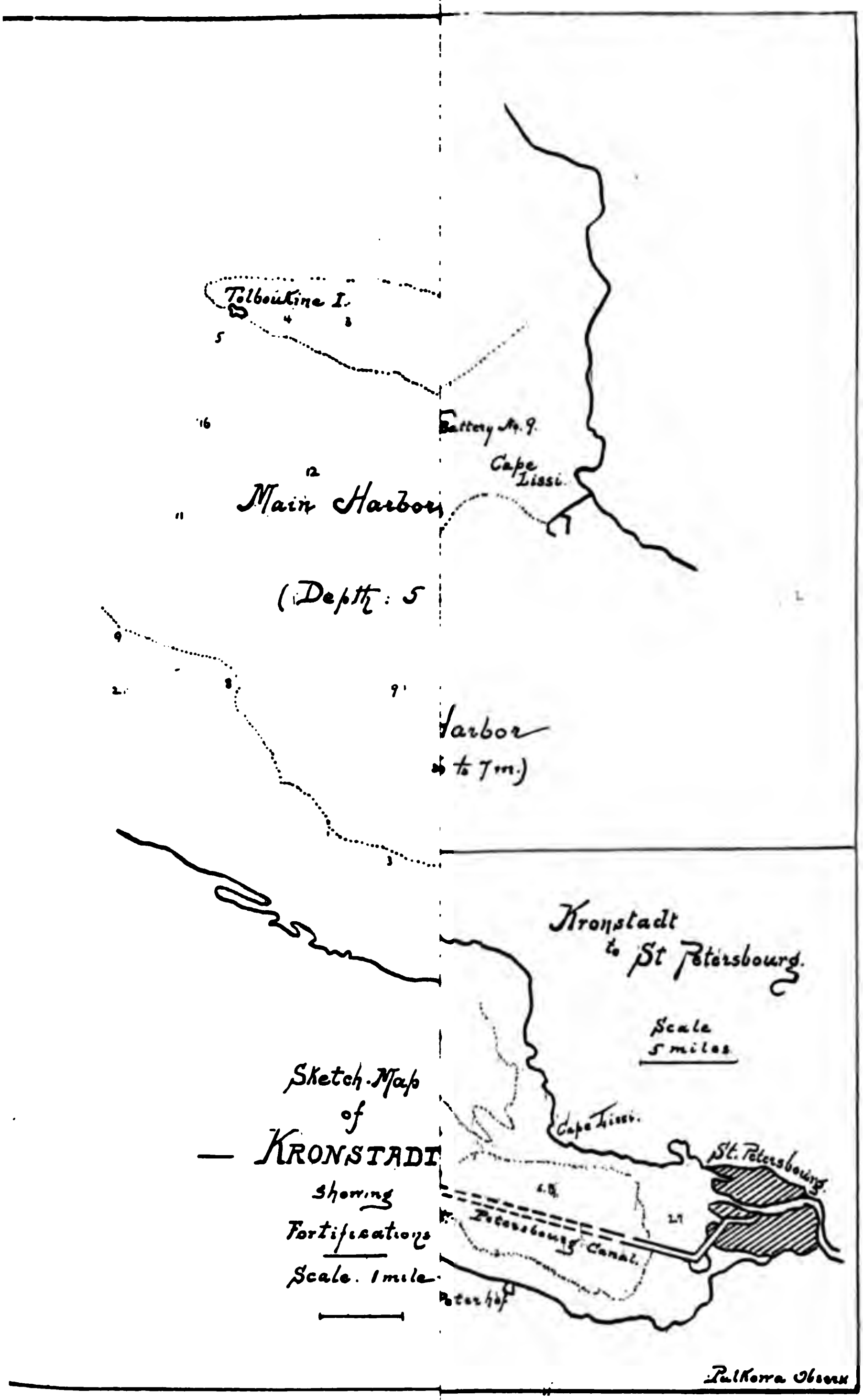
FRANCE.

(*a*) *Organization.*—The defense of the coasts is divided between the army and navy. The latter justly claims charge of this duty which it alone is in a position to direct, but the army seems not disposed to give up its share. The organization for defense in force now (1894) is, in broad lines, the following:

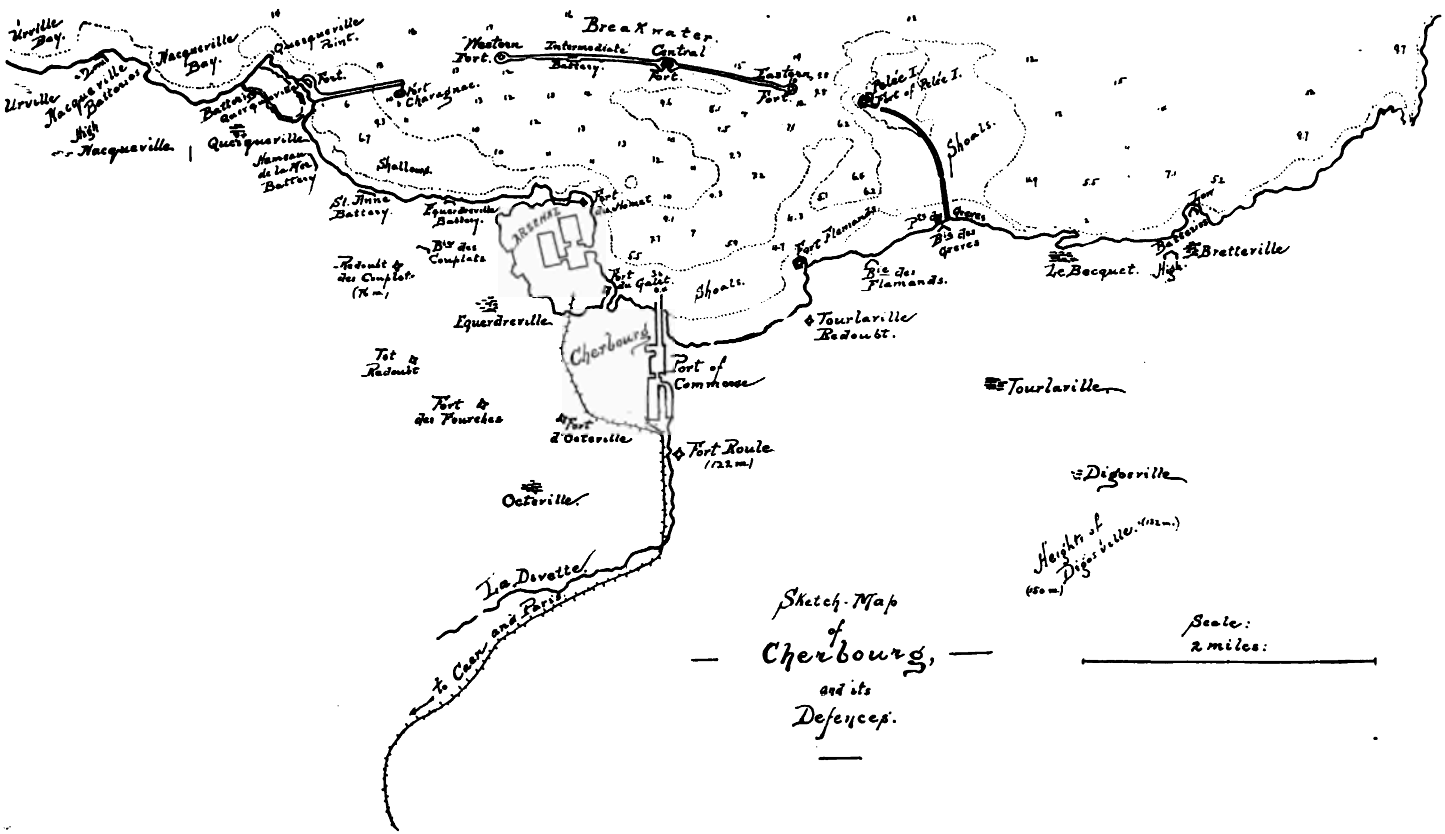
Excepting the five military ports and their approaches, the defense of the coasts pertains to the Department of War. The coast depends on the districts and territorial subdivisions of the region (*arrondissements maritimes*) which it borders; these maritime forces called to aid directly in its defense are placed under the orders of the military chiefs who command the district.

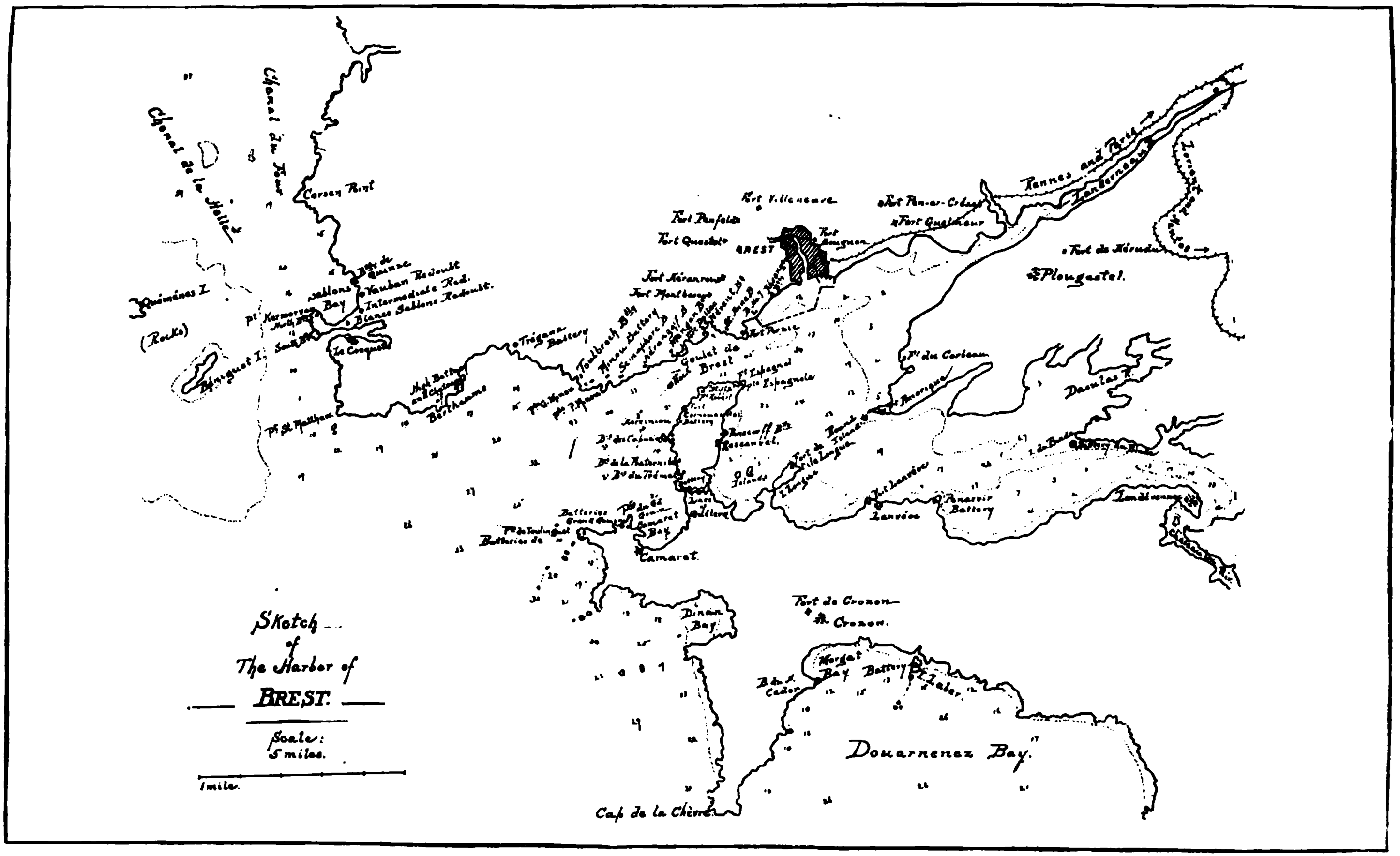
Cherbourg, Brest, Lorient, Rochefort and Toulon are the five military ports. Their defense falls to the navy. Maritime prefects, of the rank of vice-admiral, are the designated governors thereof. These general officers have command of all the land and sea forces of the place, as well as of all the works of every nature which guard or defend the approaches thereto. Around each of

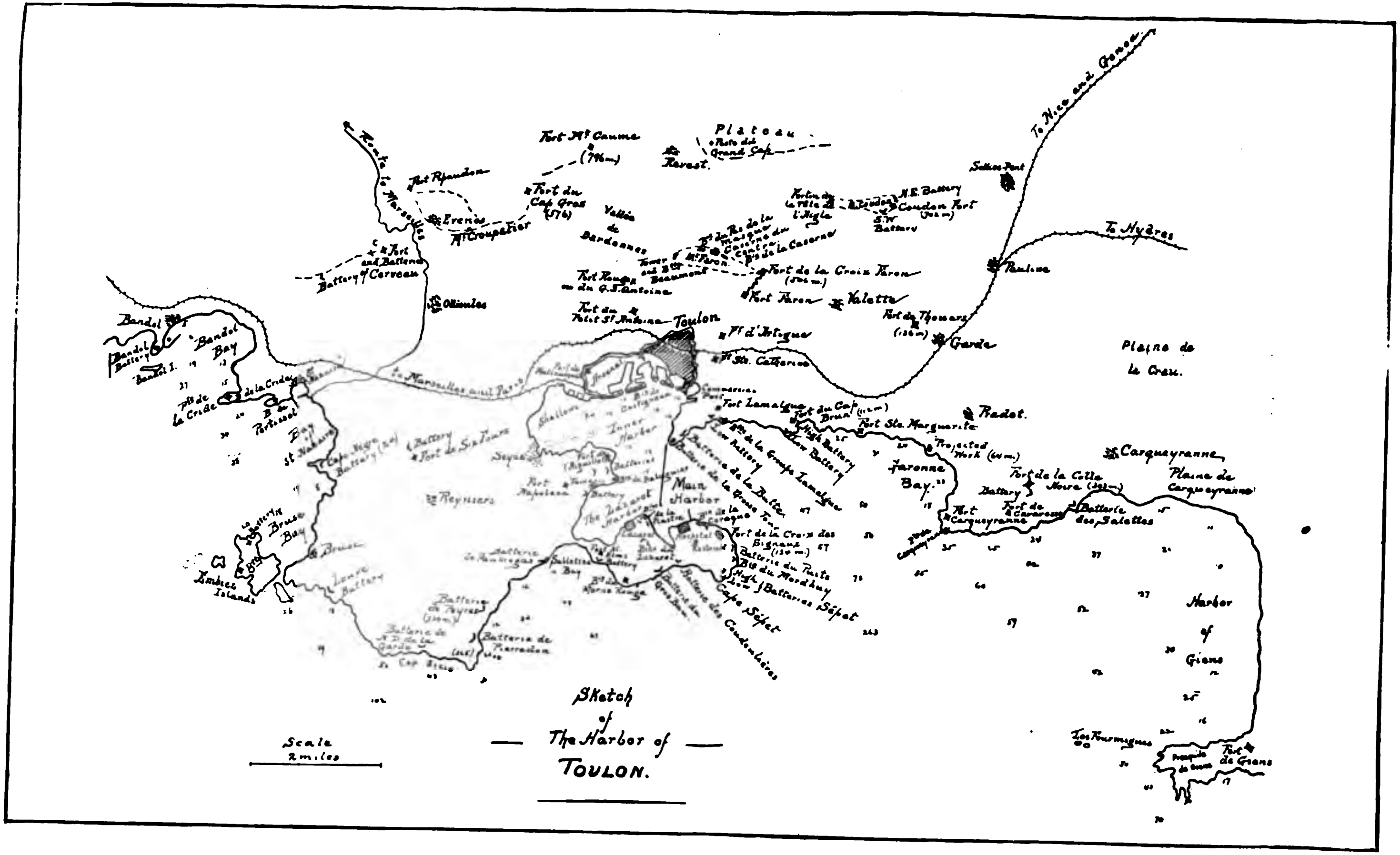

Helsingfors,
Sveaborg.
N
Degerö
Sandhamn
Batteries
Harbor of Miolo
Kalf Holm
Kungs Holmen
Ft.
Bak Holmen
East Svartö
Little Svartö
Gustafsvard
Sveaborg Fortress
Stennas Point
R.R.
To St. Petersbourg
Eastern Harbor
Langörn
West Svartö
Southern Harbor
St. Rantan
R.R.
Batteries
To Abo
Fort Braberg
Sandholm
Bussholm
Rönskar
Bty
Bty
Drumsiö
Islands and Banks
Scale: 1 mile



Tolboukine I.
Battery No. 9.
Cape Lissi.
Main Harbor
(Depth: 5
Harbor
to 7 m.)
Kronstadt to St Petersbourg.
Scale 5 miles
Cape Lissi.
St. Petersbourg.
Petersbourg Canal.
Peterhof
Sketch Map of KRONSTADT showing Fortifications
Scale. 1 mile
Pulkowa Observ.


Sketch-Map of Cherbourg, and its Defences.
Scale: 2 miles:
Breakwater.
Western Fort.
Intermediate Battery.
Central Fort.
Eastern Fort.
Pelée I.
Fort of Pelée I.
Shoals.
Shallows.
Urville Bay.
Urville
Nacqueville Bay.
Nacqueville
Nacqueville Batteries
Querqueville Point.
Querqueville
Fort.
Fort Chavagnac.
Hameau de la Mer Battery
St. Anne Battery.
Equerdreville Battery.
Equerdreville
Bie des Couplets
Redoubt des Couplets (76 m.)
Tot Redoubt
Fort des Fourches
Fort du Homet
Arsenal
Fort du Galet
Cherbourg
Port of Commerce
Fort d'Octeville
Fort Roule (122 m.)
Octeville
La Divette
to Caen and Paris
Fort Flamands
Bie des Flamands.
Tourlaville Redoubt.
Tourlaville
Bis des Greves
Le Becquet.
Bretteville
Digosville
Heights of Digosville (152 m.)
(150 m.)


Sketch of The Harbor of BREST.
Scale: 5 miles.
1 mile.
Chenal du Four
Chenal de la Helle
Quéménès I.
(Rocks)
Carsen Point
Vauban Redoubt
Intermediate Red.
Blancs Sablons Redoubt.
Sablons Bay
La Conquet
Pt. St. Matthew
Bertheaume
Trégana Battery
Goulet de Brest
Fort Villeneuve
Fort Penfeld
Fort Questel
BREST
Fort Bouguen
Fort Kéranroux
Fort Montbarey
Fort Pen-ar-Creach
Fort Guelmeur
Rennes and Paris
Landerneau
Lorient and Nantes
Fort de Kéruden
Plougastel.
Pt. du Corbeau
Daoulas R.
Roscanvel
Fort Lanvéoc
Lanvéoc
Panarvir Battery
Landévennec
Camaret.
Camaret Bay
Dinan Bay
Fort de Crozon
Crozon.
Morgat Bay
Douarnenez Bay.
Cap de la Chèvre


Sketch of The Harbor of TOULON.
Scale 2 miles
To Nice and Genoa
To Hyères
Route to Marseilles
To Marseilles and Paris
Toulon
Plateau
Plaine de la Crau.
Plaine de Carqueyranne
Carqueyranne
Harbor of Giens
Fort de Giens
Les Fourmigues
Faronne Bay.
Main Harbor
Inner Harbor
Cape Sépet
Fort Mt Caume (796m)
Fort du Cap Gros (576)
Vallée de Dardennes
Fort de la Croix Faron (506m)
Fort Faron
Valette
Fort de Thouars (136m)
Garde
Pauline
Radet.
Fort Lamalgue
Fort Ste. Marguerite
Fort de la Colle Noure
Batterie des Salettes
Fort Carqueyranne
Ollioules
Evenos
Battery of Corveau
Bandol
Bandol Bay
Embiez Islands
Brusc Bay
Bay of St Nazaire
Reyssiers
Fort Napoléon
Batterie des Coudoulières

these ports has been traced the perimeter of a zone, quite extended, called the zone of authority of the maritime prefect in command, and over which, in time of war, he exercises chief command. It comprises the immediate and distant defenses, the avenues of approach by land, the neighboring points for disembarking, etc.

The military ports are of two classes: the great ones, and the lesser ones. Cherbourg, Brest, and Toulon are the great ports; Lorient and Rochefort the lesser. They have, however, all five the same organization, only the grades of certain offices are different.

At the head of the torpedo service, with headquarters, as in all the others, at Paris, is a captain of the navy who bears the title of chief of the central service of submarine defense. In each military port, this service is similarly directed by a captain in the navy, who is director of the submarine defenses, under orders of the maritime prefect. These submarine defenses are divided into the fixed defense (lines of torpedoes, lighting of channels, the supply and preservation of gun-cotton in all its forms), and the mobile defense (torpedo boats of all kinds, armed for the protection of the coast).

"The whole system of defense for our maritime frontiers is undergoing reorganization and transformation (1884); for steam and the improvements in artillery have considerably modified the conditions of attack and defense of coasts. Our maritime frontiers are too long (about 2,700 km.—1688 miles) to have all the vulnerable points of them protected; in accordance with new principles, the desire has been to thoroughly organize the defense at some principal points, instead of stretching it out, as it was, all along the coast; a great number of the small batteries, with which our coasts were dotted, have been abandoned. * * * In France, the service of the coast batteries is performed by the land artillery, while the defense of the military ports is confided to the naval personnel." (Marga, *Géographie Militaire.*)*

(*b*) Artillery and coast defenses:

The marine artillery constructs the guns which arm the coast batteries. The principal calibers which are actually mounted in the works along the coast are given in the following table. The constant effort is to increase and strengthen or to modernize the armament of all the important places.

* See "*Latest French Regulations on Sea-Coast Defense,*" February 17, 1894, *Journal U. S. Artillery*, Vol. III, No. 3, 1894.

MARINE ARTILLERY.

Caliber in centimeters.	Weight.			I. V. in meters.
	Gun in tons.	Charge in kg.	Projectile in kg.	
34, model 1887	58	200	420	780
32, " 70, short No. 2	35	68.5	345	435
32, " 70, long No. 1	39	86	345	471
32, " 70-79	42	86	345	495
32, " 70-84	48.2	139	345	605
27, " 70	23.2	42	216	434
27, " 70 M	23.2	62	216	490
27, " 1881	27.9	91	216	600
27, " 70-87	30.2	91	216	600
24, " 70	15.7	28.5	144	440
24, " 70-87	20	68	144	600
19, " 70, long	8	15.6	75	448
Muzzle loading mortar, 30 cm	10.7	16.8	219	Variable

It may not be out of place, were it only for comparison with the preceding, to give also the following table of the Canet artillery, built both for coast batteries and the armament of ships:

CANET ARTILLERY.

Caliber in centimeters.		Weight.			I. V. in meters.
		Gun in tons.	Charge in kg.	Projectile in kg.	
37	50 calibers long.	128.3	440	620	800
34		99.6	340	480	800
32		83	284	400	800
30		72	250	350	800
27		50	170	240	800
24		35	121	170	800
22		27	92	130	800
19		17.4	60	84	800
16		10.4	36	50	800

Among France's sea-coast defenses, many works of old type and construction are found. They consist of forts, bastioned works and batteries, of granite or of earth, or both; in some cases, of earth with scarps and counter-scarps revetted with uncut stone. In most of the ports, the advantages of great command is obtained, the coast being high and rocky; and here we find *high* batteries, protection not so necessary, and *low* casemated batteries. The defenses are being strengthened and re-equipped to fulfill new requirements, and in the important places, no expense seems to be spared in making them as complete and strong as possible.

(*c*) Special considerations:

CHERBOURG.—Towards the sea, starting from the east, there are eight works (forts and batteries) commanding the approaches of the harbor, their main object being to prevent the bombardment of Cherbourg by hostile ships. The five on the breakwater are of granite.

Two more forts and the groups of batteries of Querqueville and Nacqueville complete this line.

The guns of eight works bear upon the inner harbor. These are batteries and forts of old design and construction.

On the land side there is a cordon of seven forts and redoubts, the only one of value being Fort Roule (alt. 122 m.). These defenses are insufficient and too near the city. A completely new plan of permanent forts has been devised occupying a line much in rear.

BREST.—This is the great military port on the Atlantic. It is most strongly fortified. The exterior sea-defenses are those of Blancs-Sablons, Berthame and Camaret, and Morgat. Fort Crozon is a new fort and commands the whole peninsula.

The entrance of the *Goulet* is defended by five batteries to the north and five to the south, covering especially Camaret Bay favorable for disembarkments.

The defense of the *Goulet* itself consists of about fourteen batteries; these are *high* or batteries for bombardment, (plunging fire) and *low*, many of which are casemated, (direct fire.) Many forts and batteries protect the harbor and port (twenty altogether, strongly armed.)

Of the land defense, some of the works date from 1777. With the exception of Fort Portzic they are of little value today. But forts Pen-ar-Créach and Guelmeur are recent works.

"The High Committee (*Comité Supérieure*) on defense has not admitted the probability of an attack on Brest from the north, and was of the opinion that it would suffice to oppose the operations of an enemy disembarked on the Bay of Douarnenez. With this end in view, they decided on the construction of two forts: Crozon now completed, and Kérudu on the Plougastel peninsula, still in the projected state."

As can be seen, the defenses of Brest against an attack by sea are most complete and well organized, and it is not altogether defenseless from an attack by land. Besides being able to depend on the works already finished and those that will soon be completed, it can rely, to a very great extent, on the natural obstacles of that part of the country.

TOULON.—This is the only French military port on the Mediterranean and, at the same time, the most important of all the five. It is the indispensable base of supply of the Mediterranean fleets, the defensive base of Provence, the defensive support of Marseilles and, to a certain extent, of Nice. It is here that the greatest effort has been made to put its defenses into shape commensurate with the importance of the rôle, that the port will be called upon to fulfil in time of war.

The defenses of Toulon, along the sea-coast, consist of forty forts or batteries. They may be divided into two groups, those to the south and west of the entrance (to the left) and those to the north and east (to the right). The former serve to prevent disembarkments at Brusc, Saint Nazaire or Baudol, and defend the Bay of Sablettes. Fort Croix-des-Signaux (alt. 134 m.) is an important work, very strongly armed. The second group defend the harbor itself, and those to the right of the entrance cross their fire with corresponding batteries on the southern peninsula. They all protect the main harbor, and cover the anchorage of Vignettes, and Garonne Bay, under Carqueyranne Point.

Two concentric lines of works defend the city from the land side. The inner line, of about 13 forts, is complete. The works of Faron (alt. 546 m.) form the key of the position: three forts and four batteries, of large size and well equipped. Nine forts or groups of works form the exterior line that has been but recently finished. The works of Coudon (alt. 720 m.) are the most important. The whole line of land and sea defenses about Toulon has a length of 56 km (35 miles).

The possession of the position Nice-Villefranche (one the key at the defense of that part of the frontier and the foreseen objective of certain attacks, the other an excellent harbor only a few miles from the Italian frontier) being of the greatest value to France, nothing has been spared to render it impregnable in case of war. At Nice, strategic railroads follow the crests of the hills, facilitating the defense and occupation of strong positions which command the environs of the place, and which have been covered with works powerfully armed. Four works constitute the advanced line, and seven the one in rear nearer the city. Towards the sea, it is protected by the works of the Bay of Villefranche, six important batteries.

To within recent years Nice was connected with the French system only by the line of the coast, one easy to cut. The construction of an inner strategic railroad from Nice to Puget-

Théniers and Digne has obviated this danger. A second strategic line connects Nice directly to Toulon through the interior, passing through Grasse and Draguignan, and completes the defensive organization of this important place.

Lorient is not strongly fortified. It is without defenses on the land side and along the coast are six forts and two batteries.

Rochefort, headquarters of the 4th maritime arrondissement is an important construction depot. It is well defended against an attack by sea by about thirteen forts and batteries along the coast. They are mostly old works however. Fort Bayard is a massive circular construction of masonry with several tiers of fire. The post is exposed, unfortunately, on the land side.

The defenses of Marseilles have been, of recent years, put in good condition and thoroughly repaired and re-equipped. There are about eighteen forts and batteries (high and low) for its defense. As formidable as they may be, they do not, however, protect the city completely from an attack by sea. But supported by a good maritime mobile defense, they would be of great value in time of war.

"Our five military ports are sufficiently well protected against bombardment from the side toward the sea, either by the natural difficulties of the channels that have to be followed in order to enter, or by the fortifications that have been continually added there; however, Cherbourg could be bombarded from the open sea, and the difficulties which would be met with in entering the harbors of Brest and Toulon, are less great than those which protect many of the great military ports of England or Germany: Portsmouth, Kiel, etc.; Lorient and Rochefort are more inland, but these two ports are much less important and of less value than the three others.

"Many of our great ports of commerce, Marseilles, Boulogne, Havre and Saint Nazaire, are also greatly exposed to bombardments. This mode of attack would result in ruining our commerce, at the same time in enriching the enemy by the contributions which he would not fail to levy on our cities."

(TO BE CONTINUED.)

Lieutenant ANDREW HERO, JR.,
Fourth Artillery.

THE BICYCLE AND ITS ADAPTABILITY TO MILITARY PURPOSES.

(Continued from the September-October *Journal*, Vol. VI, No. 2.)

PART II. THE MILITARY BICYCLE.—*Concluded.*

Types of Military Cycles.—Up to the present time it may be said that few attempts have been made either at home or abroad to build a bicycle distinctively for military purposes. The experiments thus far made, with some modifications to be hereafter mentioned, have been conducted upon the commercial wheel, with perhaps the addition of a few contrivances for carrying the soldier's baggage and accoutrements. It has been only quite recently that the necessity of a special wheel for military service has been clearly seen, and it would seem to offer a good field for the inventor.

We have already spoken of the early experiments made in Italy in military cycling. This was before the advent of "the safety," and the only use which the bicycle was then thought capable of fulfilling was the service of courier or estafette. We give here a cut of a French courier, which we reproduce from a wood cut of about twelve years ago.

The employment of cyclists in considerable numbers as combatants, it would appear, was first thought of in England. To avoid the lengthening out of the column, and to enable the cyclists to mutually assist each other in riding over uneven ground, Messrs. Singer & Co., well-known English bicycle manufacturers, proposed and built a multicycle, consisting of a number of pairs of wheels all united together by a connecting line.

The cut gives a very fair idea of this machine, and the use it was designed for. A glance is safficient to show its utter impracticability. A few machines of this kind would occupy as much road as an army corps, and would possess about as much mobility as a train of elephants.

In the U. S., the little that has been accomplished in the way of military cycling has been brought about by using the common safety. A detachment from Fort Sheridan was thus mounted a few years ago, and various militia signal companies, and others are similarly equipped. The results so far are encouraging, but not altogether satisfactory.

For the past three years the Remington Arms Co. has built a military model wheel, furnished with clamps for carrying a Lee rifle, knapsack and blanket. A special feature of this model was the finish, the enamel being a dead lead color and the metal parts black-brown, similar to that used on military rifle barrels and bayonets.

Several other American firms. notably the Pope Manufacturing Company, have likewise fitted wheels for military use. At the New York Cycle Show, last spring, this latter company exhibited their model 40 "Columbia" (standard road machine) equipped with a Colt automatic machine gun, weighing 40 pounds. The cut (furnished through the courtesy of the company) makes clear the arrangement. The following we take from a newspaper account at the time: "If (the gun) is so well placed that it can be fired with the greatest possible ease, whether the rider be going fast or slow, and no matter how bad the roads are. The gun, which was recently adopted by the U. S. Navy, is of one barrel, attached to the breech casing, in which the mechanism for charging, firing and ejecting is contained. It is automatically

fed by means of cartridge belts which are coiled in boxes readily attached to the breech casings. The boxes contain 250 cartridges each, and are so constructed that they can be quickly attached or removed.* In a recent test for accuracy at 200 yards, 100 consecutive hits were made in 16 seconds."

We are not told where the ammunition to supply this voracious gun is to come from, but this would be an important matter; else the very rapidity with which the gun can be fired would be a disadvantage. No doubt there would be occasions, especially in a street riot, etc., where the moral effect of such a weapon would be very great; and it would thereby perform handsome service; but we may dismiss such an arrangement from the field of regular military cycling, reserving it for the special occasions remarked.

* New York *Sun*.

This company also exhibited at the same time a tandem designed especially for signal use. As will be seen from the cut, it carries on either side of the machine two Colt 12-shot repeating carbines, resting in leather-lined, steel enamelled gun rests, from which they can be removed in a moment; two six shooters are likewise secured in holsters attached respectively to the front and rear seat posts; a jointed flag staff is carried in a canvass case shown on the right side beneath the carbines; while the front and rear handle bars carry respectively rolls consisting of two overcoats and two pairs of regulation blankets. "The guns,

revolvers and all are so ingeniously attached as not to interfere in in the slightest degree with the riders, and the additional weight is hardly perceptible in driving the machine.

Captain R. E. Thompson, Signal Corps, U. S. Army, has devised an attachment for laying or taking up the cable of a field telephone or telegraph.

(Cut taken from photograph furnished through courtesy Chief Signal Officer.)

It was found that by throwing insulated or naked wire on the ground, preparatory to establishing communicating stations, the reel of wire was so heavy that it had to be carried along in a cart. This required two men, one to push the cart and the other to unwind or rewind the wire. By fixing the reel on the bicycle, the rider is enabled to lay or take up the wire continuously, and at a good rate of speed.

Instrument cases are also carried, so that connections can readily be made with the line at any point.

"The same automatic device is being fitted to an outpost cable cart, three of which have been ordered, from which are confidently anticipated equally good results as in the case of the bicycle."*

Abroad it would seem that the matter of military cycling has been on about the same footing as in this country. There have been many who have advocated the use of the wheel for combatants, but it has been only within the last year or so that this proposition has received the serious consideration of the authorities. The maneuvers in Germany, France and elsewhere, seem to have demonstrated beyond cavil the importance of the service that the military wheelmen can perform under favorable conditions; and nearly every European country has adopted a bicycle of some form or other. With few exceptions, these machines do not differ much from the models in common use, and an undue conservatism has caused, in nearly every instance, the retention of the old style tire, rendering the machines, as we have already noted, extremely cumbersome and heavy. The French, so far, seem to have recognized most clearly the conditions which surround military wheeling, and it is to that country that we must look for the most advanced ideas in this regard.

In one of the later numbers of the "Revue du Cercle Militaire" for 1893, an article by Lieutenant H. Gérard, of the French Army, discusses from a theoretical standpoint, the possible employment of the bicycle in the military service. In this article the author lays down the general principle to which we have already referred: "That the military bicycle must be built to fullfil the condition that wherever it cannot be made to carry its

* Report Chief Signal Officer, 1895.

rider, the rider must be able to conveniently carry it." Following out the idea here advanced, M. Charles Morel, a French master-mechanic, constructed a "folding bicycle" that can easily be doubled up upon itself into a compact shape, and then slung from the shoulder like an ordinary knapsack. We reproduce several cuts of this machine, taken from the "Revue,"

showing it when folded as well as when extended. As will be seen from the cuts, it presents several novel features, chief of which are the device for folding and the location of the saddle directly over the rear wheel axle. This last feature, which seems so strange to us, is claimed by the inventor to be of great value.

Thus, while the strain brought upon the rear wheel is very great, it is met by sufficiently strengthening the same; while the front wheel, being relieved in great part from the weight usually resting upon it, rides freely over obstacles, preventing serious injury to the fork and the frame of the machine. It is also claimed

that the weight resting so nearly over the point of support of the rear wheel does away, to a large extent, with the dangers of side slipping, while facilitating the steering qualities of the machine. Likewise, the seat is placed very low, so that the feet rest upon the ground when they are taken from the pedals, and thus it is possible to bring the machine to a dead halt in column without dismounting from the saddle; to accomplish this, the driving crank axle has to be placed very far to the front, and the machine is driven more by leg-thrust than by the rider's weight. The machine is equipped with pneumatic tires, which renders it possible to bring the weight down to 12 kilograms (about 27 pounds.)

It can be folded and slung, or unfolded and extended for use, all well within one minute.

Within the last year it has been proposed to join two of these machines together, as shown in the cuts. This, it is said has been practically accomplished, and with gratifying results. The following advantages are claimed for this method:

1. The machine is rendered stable, and can be ridden by comparatively inexperienced men;

2. It affords a method of bringing away a wounded comrade;

3. It economizes to the highest degree the road space;

4. It affords a convenient method for carrying supplies and accoutrements, together with high explosives, simple tools, etc., for hasty demolition;

5. It does away with the danger to side slipping, and renders it possible to ride the wheel even where the ground is very wet and slippery;

6. They are bound together by light stays removable in a moment's time, and then the machines possess all the mobility of single wheels, aud can be folded as before.

We shall elsewhere give some account of the practical use of this machine. Right here it may be fair to make remark upon a few points which, it would seem, might be improved.

1. It is to be noted that the objectional chain is retained. This (while perhaps not so important a matter in France as here) should, if possible, be avoided.

2. The form of frame, consisting of but a single piece of tubing connecting the front fork with the rear wheel, and this too, containing a joint, impresses one as being a rather weak construction.

3. The position of the pedals with respect to the rider's seat

seems to us very awkward, and would not appear to be such that he could use his strength to best advantage.

Another type of French folding bicycle, the "Noel," has also been experimented upon. It is of the front driving safety pattern, the forward wheel having a diameter of twenty-two inches and the rear wheel a diameter of about one-half this. The driving mechanism, in this case, is all enclosed in a dust tight gear case. The back bone is hinged at about the middle, and the rear wheel is thus allowed to fold over the forward, and the whole machine is then slung from the shoulder as already described. This machine would seem to possess many valuable features.

For many reasons I believe that "the tandem" will be found best adapted to military use. These reasons, in part, are:

1. It is a well known fact that a tandem can be built to carry two riders with less weight than the combined weight of two single wheels of equal strength. This is due to the fact that there are only two wheels in the tandem as against four for the individual mounts, and no very great increase in the amount of tubing required. The saving thus made more than compensates for the increased weight of the tubing, etc., necessary to give the tandem strength to carry its greater load. Thus, while the commercial light road wheel weighs from 23 to 25 pounds, the corresponding tandem weighs only 38 to 40 pounds.

2. The tandem requires less effort on the part of its riders.

We have already discussed the resistances which impede the bicyclist, and of these the two most important are due to rolling friction, and to the opposition of the air. In the case of rolling friction, it is plain that two riders on independent wheels *make two tracks*, while but one track is made by the tandem; so that the work done in deforming the ground, that is, the work due to rolling friction, is evidently much increased by the use of separate wheels.

Likewise, as regards the matter of air resistance, the two riders, close together on the tandem, oppose sensibly the same surface to the air that would be offered by *each* on separate wheels. So, too, here is a great gain. While I know of no exact dynamometrical experiments bearing on this question, it is generally considered, by those who have had much experience in the use of bicycles, that the work done by each rider, in covering a certain track under otherwise similar conditions, is about 25% less on a tandem than it would be for him on a single wheel; and we

see this fact recognized in the higher gears with which manufacturers equip their tandems. Taking this estimate then, as a basis for comparison, it would seem that if. as we have shown, a distance of 50 miles daily, day in and out, can on a good road be exacted of the military cyclist on a single wheel, a distance of 62 miles could with equal propriety be demanded of the riders of the tandem. If the gear of 56″ be the most suitable for economy of strength on the single wheel, the corresponding gear of the tandem should be between 65 and 70; and it would likewise seem that the adopted speed for the single wheel of 7½ miles per hour could be raised, with equal economy of strength, on the tandem to nearly 9 miles per hour, while *the maximum* speed of 15 miles per hour could be increased to about 20 miles per hour.

Thus it would seem that the tandem affords a substantial increase in the rate of speed and the distance travelled in a day by the cyclist; or a compensating economy of strength; while the fact that a much higher speed can be maintained on it for short intervals, would make it specially advantageous in escaping from a sudden danger, or in the rapid carrying of despatches.

3. The tandem affords a great economy in road space. Since the distance between machines need be no greater in this case than with the single wheel, there results that twice as many men may be transported to the mile, and this, whether the machines are in single file, or in a column of twos, threes, or fours.

It must be apparent to everyone that in this respect the military tandem possesses great superiority over the single wheel.

4. On the single wheel, the rider must necessarily pay close attention to steering his machine, and the more difficult the ground, the greater the peril, or the higher the rate of speed, the more closely must he devote himself to this task. The tandem affords the very great advantage that while one man steers, the other is free at all times to observe everything that is going on, and may, if necessary, easily release both hands from the handle bars, and employ weapons for their mutual defense.

5. The tandem makes it possible to employ bicyclists in much the same way as dismounted cavalry. It is possible for one man to ride one wheel and "lead" another, so that when cyclists come in action, they might, dismounting, leave one man in every four, as "wheelholder," whose duty it would be to look out for two tandems, and bring them up in time to join in the pursuit, should the attack prove successful. With individual wheels the proportion of men for wheelholders would be too great, generally, to permit this maneuver; rendering it necessary for the whole

command to dismount, fight, and then return—perhaps a long distance—for their wheels.

6. During bad weather, or in a country where the roads are such that bicycles cannot be employed with profit, it has been proposed to transport them on light vans constructed for the purpose. With a properly constructed van it should be possible to transport as many tandems as single wheels, thus saving, for a given number of cyclists, half of the requisite transportation.

Also, for a given body of cyclists, there being only half as many tandems as single wheels required, the chance of accident is divided by two; likewise, it will be necessary to provide but one half as many spare parts to safe-guard against accident.

7. Experience proves that soldiers in the field are apt to pair off and share each other's fortunes,—marching, cooking, and sleeping together, making common use of their several effects, and so not only minimizing their loads, but adding much to their mutual comfort. If one rider is entirely disabled, the efficient rider can, nevertheless, ride off with the tandem almost as well as he could with a single wheel; while in case his companion is merely sick or slightly wounded, he may be able to bear him away to a place of safety. We must not under-estimate the value of the moral support which such companionship affords, in moments of peril, nor the value of the assistance which two men may mutually extend in case of accident. The principle is well recognized, as we may find in the posting of double sentinels and the employment of scouts in pairs. The bicycle service, it may be expected, will be of a similarly arduous and dangerous character, and it would seem that the same principle could be most advantageously extended to the mounting of two riders on a single wheel.

The principal objections urged against the employment of the tandem for military purposes, other than those already advanced against the commercial wheel, are as follows:

1. It is seriously alleged that two riders ou the same wheel could not get along harmoniously; that one would surely attempt to shirk, and that complaints on this account would be never ending—cases of this kind, it is probable, would be exceptional, and as the bicycle service would undoubtedly be popular, to assign their machine to others would be a sufficient remedy.

2. A more reasonable objection is that the excessive length of the tandem makes it awkward to handle, both in picking the way along difficult roads and footpaths, and in carrying the wheel by hand. The great distance between wheels renders it a

difficult problem to provide a frame of sufficient rigidity; for as in the similar problem in engineering of a girder loaded at the middle and resting on two points of support, the bending moment increases with *the square* of the length. Particularly is this noticeable in securing the requisite lateral stiffness, whereby the proper tracking of the wheels is maintained. The side draft of the chains, irregularities in the slope of the ground, and the lateral thrust, or centrifugal force in rounding corners all tend to twist the frame, and throw the wheels out of true. The first of these difficulties is partially overcome in the tandem built by the Remington Arms Company.* Here, as seen in the cut,

the lower longitudinal braces are double, and the forward driving chain is symmetrically disposed between them.

The necessity of securing lateral stiffness has compelled manufacturers to make the frames of their tandems considerably heavier than would be otherwise necessary.

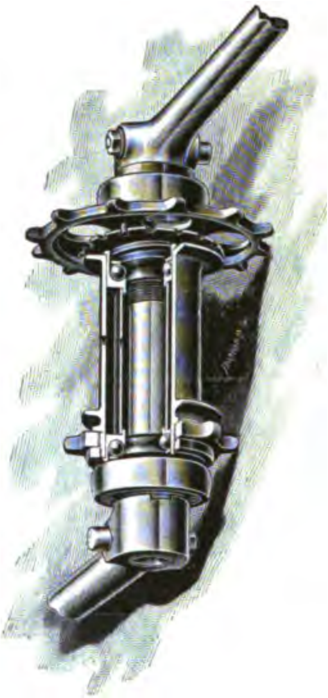
What seems to us an advanced step in tandem construction is shown in the subjoined cut.† Here the chief feature that impresses one is the shortening of the wheel base by placing the rider well to the rear, and over the rear wheel. In fact the wheel base is but about five inches longer than that of the single wheel, as turned out by many manufacturers. The rear crank axle, revolving independently of the wheel, is connected with the forward crank axle by means of the chain shown on the right hand side; while the chain on the left connects this axle with

* Cut furnished by courtesy of Remington Arms Co.

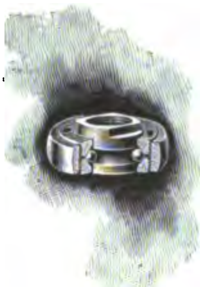
† Cut furnished through courtesy of the makers, "Tally-Ho" Tandem Co., Toledo, Ohio.

the sprockett attached to the rear wheel, and furnishes the necessary multiplication for speed. Thus the two chains, unlike the case with the ordinary tandem, tend to equalize the draft on the rear axle, eliminate the side draft altogether, and add greatly to the general staunchness of the construction. The section of the rear crank and hub bearings will sufficiently illustrate the novel features of chain action in this machine.

The two handle bars are connected together by the tension rods and chain, shown in the diagram, and move in unison, as is the case with most other tandems. I can say from personal



Rear Crank Axle and Hub Bearings.

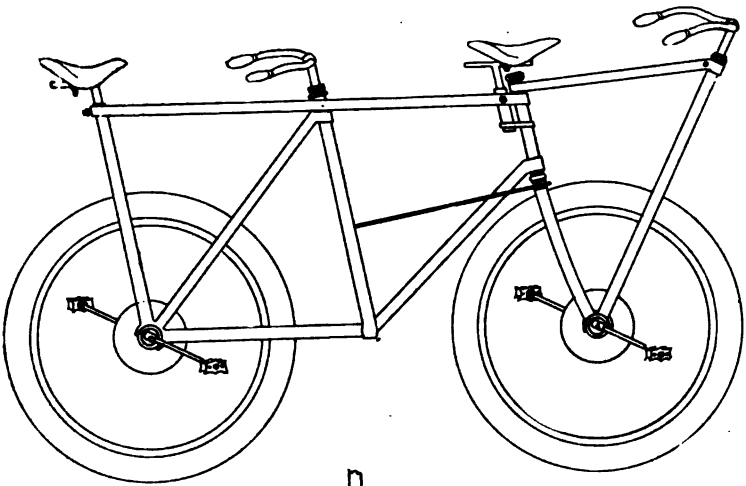


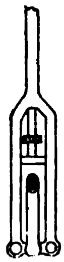
Section of rear bracket self-adjusting sleeve.

experience that it is easy to catch "the swing" of this machine, and that it steers and handles nearly or quite as well as a single wheel, and seems much more manageable than the ordinary tandem. A few hours' practice is all that is necessary for two riders to become thoroughly expert in its use. For general purposes I would place this tandem far ahead of any that I have seen, in point of strength and general manageableness; and if not, as now made, entirely adapted to military cycling, it at least, in my opinion, suggests the proper line for the development of a military machine.

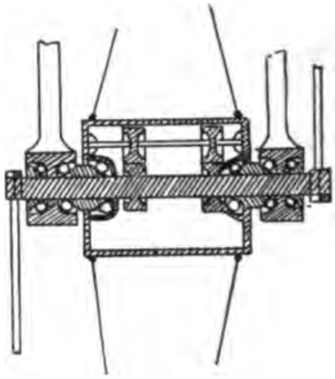
We give here a cut of a military tandem designed by an

officer in our service. The sketch is intended not so much to show the mechanical details of construction, as to illustrate the underlying idea of the mount.





The rider on the seat drives directly on the crank axle of the forward wheel, which is geared up to the proper speed by means of suitable gearing in the gear box of the axle. Any kind of gearing that accomplishes this purpose will do. The gearing illustrated (shown in section) is a simple epicycle gear, giving two revolutions of the wheel to one revolution of the axle. This could, as is evident, be varied at will. So far as the front rider is concerned, the wheel resembles the "geared ordinary," in analogy to which, indeed, the construction is made. Its steering qualities, therefore, should be good; and the machine should be capable of being ridden by a single rider almost as easily as the one-seated safety. The two wheels are connected by the Humber frame, admittedly the strongest and most rigid frame extant, and the wheel base is the same in length as it is in the single safety, thereby lending great lateral stiffness. The rear rider sits over the rear wheel, and drives on an arrangement similar to that described for the leader.



[Sectional sketch of gear box and axle.]

The special advantages claimed for this mount, from a military standpoint, are:

1. Compactness, strength and lightness. The machine is no longer than a single safety, and requires but a little more material in its construction. Moreover the weight of the riders is borne, almost entirely, directly upon the wheels, and the frame is thus relieved in large part from strain. The large barrel hubs employed conduce to strength, and make it possible to have a very narrow "tread," and at the same time (from the great lateral divergence of the spokes) assure the wheels great lateral stiffness. The triangular arrangement for the front handle-bar-support should greatly stiffen the front fork. The relatively large tires employed mitigate vibration, relieve the frame from strain, and possess the other advantages which we have previously discussed.

2. *The elimination of the chain*, and enclosing of the bearings in a dust proof gear-box, are important gains. This construction adds greatly to the simplicity of the machine, and at the same time facilitates cleaning and repair. The frame is designed so that the wheels may be removed in a minute's time, and the gear box is such that it may be speedily taken apart whenever necessary. It is well known that accurately cut spur wheels are now made, even with as few as 12 teeth, that run with exceedingly little friction. It is probable that the gearing proposed would at all times run with less friction than exists between the chain and sprockett wheels of most constructions, and surely would after the latter had become worn by dust and exposure to the weather.

The oiling arrangement is greatly simplified, for by simply making the axles hollow, closing their ends with suitable oil plugs, and filling the space with some sort of absorbant wool,

the oil may be led from this receptacle, through radial holes drilled in the axle, to every portion of the gearing needing lubrication; and these parts would constantly receive such oil as is required, with none superfluous and oozing out to retain dust.

3. Portability. By inserting hinges in the frame, with a suitable locking device, as is done with some commercial wheels with this style of frame, this tandem may be folded together and easily carried by one man. It is thought that its weight need not exceed, for even the roughest service, forty pounds. If now the equipments which the riders would carry were made into one package, it would also weigh about 40 pounds, and might be quickly attached to the machine by suitable snaps. One of the riders, therefore, might sling the equipment over his back, the other the machine, and thus they might transport their combined effects wherever such alternative was found necessary.

In concluding this portion of our subject, we repeat that the construction of a bicycle specially designed for the military service is the first and most important problem immediately connected with the subject of military cycling. And until this is definitely and satisfactorily solved, we do not believe that any great advance is possible.

It is with the hope that they may afford some suggestions towards the accomplishment of this purpose that the foregoing pages have been written.

Lieutenant William C. Davis, 5th Artillery.

FIELD SHRAPNEL AND CANNON OF THE FUTURE.

Based on a study by General Rohne, of the German Artillery.
From *Revue d'Artillerie*, May, 1896.

Under the title: Studie über den Schrapnel-schuss der Feldartillerie, General Rohne, commanding the 8th brigade of the German field artillery, has published an important work on field schrapnel, in which he examines the various factors that influence the efficiency of this projectile, and seeks to draw practical conclusions from the point of view of a rational arrangement of it.

On account of the competency of this author to speak on all questions concerning artillery, and of the fame he has acquired in Germany by his previous works, we have thought it would be interesting to give a résumé of this study.

Shrapnel is now the principal projectile in field artillery, and it will doubtless be so for many years; it is natural for us then to examine thoroughly the mode of action of this projectile and to determine the conditions under which it attains its maximum efficiency.

A STUDY OF THE VARIOUS FACTORS INFLUENCING THE EFFICIENCY OF SHRAPNEL.

The effect of shrapnel is very different according as the opening of the sheaf is greater or less. But this is far from being the only element for estimating the value of a shrapnel; to study the problem in its broadest sense, and to determine the improvements that might be made in the construction of this species of projectile, we must successively examine the following points:

1. The number of bullets the projectile contains.
2. The penetrating power of these bullets.
3. The dispersion of the bullets, or rather the angle of opening of the sheaf.
4. The dimensions of the objective against which the shrapnel is to act.
5. The inclination of the trajectory at the point of the burst.

We will see in the course of this paper the part which these various elements play in the operation of the shrapnel.

Number of bullets.—The number of bullets contained in a shrapnel depends primarily on the weight and mode of construction of the projectile, but also on the weight of each bullet.

Other things being equal, the larger the shrapnel the larger is the ratio that the weight of the charge of bullets bears to the weight of the projectile. Or to put it in another way, if we compare several projectiles constructed on the same principles, the heaviest will be more advantageous than the lightest, in that it will contain proportionately more bullets. This law has been long known, and it is not necessary to dwell on it.

The mode of construction of a shrapnel is at least as significant as its weight in fixing the number of bullets it will contain. From this point of view, the shrapnel now in use can be divided into three categories according as it has the powder charge in rear, in the center, or in front.

Each of these types has its advantages and its drawbacks.

With shrapnel having the charge in the base, the charge on bursting imparts a certain velocity to the bullets which increases the velocity already possessed by each bullet, and tends also to increase the length of the zone covered by the sheaf. But to make a sensible increment in the velocity, the bursting charge must be large, and thus it occupies space that would otherwise be filled with bullets. Besides this, the necessity of separating the balls from the powder by a diaphragm, and of leaving a channel between the fuse and powder charge, still further reduces the space available for bullets.

In shrapnel having the bursting charge in front, and especially in the *obus à mitraille* pertaining to this class, the explosion of the charge tends to diminish the velocity of the bullets, which causes a diminution in the length of the zone covered, and an increase in the angle of the sheaf.

This last effect is also produced by shrapnel having a central charge.

The metal of which the body of the projectile is made is also of importance, for the more resistance it is capable of, the more we may reduce the thickness of the walls. Thus the substitution of steel for cast iron has increased the interior volume of German shrapnel from 15 to 20 per cent.

The following table contains the principal data required for a comparison of these various types of shrapnel:

This table shows that the number of the bullets is not alone sufficient for judging the value of shrapnel; the weight of each bullet must also be taken into account. These two multiplied together give the total weight of the bullets, that is the *useful weight*, which evidently should be as high as possible.

Mode of construction.	Nation or Firm.	Date of placing in service.	Caliber.	Weight of shrapnel.	Number of bullets.
			mm.	kg.	
Central charge.	Germany [1]	1882 1891	88 88	8.15 (7.5)	262 (279)
Base charge	Austria	1875 1875	87 75	7.16 4.80	165 105
	Russia	1877 1877	107 87	12.50 6.85	345 167
	Italy	1881 1881	87 75	7.00 4.50	177 109
	Switzerland	?	84	6.70	185
	Spain	1880 1890	78.5 78.5	6.43 7.26	231 231
	Krupp	1891 1891 1895	60 80 75	3.00 7.00 6.50	100 205 250
	Gruson	1895 1895	53 75	2.00 7.00	 192
	United States	1889 1889	81.3 91.4	6.10 9.07	170 ?
	England	?	76.2	6.80	252
Front charge.	England	?	76.2	5.67	177
Obus à mitraille.	France	1883 1883	90 80	8.68 6.28	2[illegible]7 [4] 162 [4]
	Hotchkiss	1883	75	6.00	231
	Canet	1883	75	6.00	177

(1) The numbers in parenthesis do not appear in the table of General Rohne; they are taken from *Waffenlehre* (Berlin, 1896) published by General Wille, or are calculated from data in that work.

(2) 11.1 grm. according to General Wille.

(3) 11.1 grm. being taken for weight of the bullet.

(4) Bullets or fragments.

Weight of one bullet.	Total weight of bullets.	Ratio of weight of bullets to weight of the shrapnel.	Weight per square cent. of section.	Ratio of the weight of the projectile to that of the solid cannon ball of the same caliber.	BURSTING CHARGE.		Initial velocity.
					In grammes.	In thousandths of the weight of the projectile.	
grm.	kg.		grm.				m.
13.0	3.41	0.418	132.6	3.23	22.5	2.7	419
11.0 ([2])	(3.10) [[3]]	(0.413)	(123.3)	3.00	(19.0)	(2.5)	442
13.1	2.16	0.30	120.4	2.97	85.0	11.9	430
13.1	1.37	0.28	108.7	3.08	45.0	9.3	409
11.0	3.76	0.30	142.7	2.88	110.0	8.8	374
11.0	1.83	0.27	119.1	2.93	68.0	10.6	442
13.0	2.29	0.33	117.0	2.88	80.0	11.4	448
13.0	1.42	0.30	101.0	2.89	50.0	11.1	423
12.5	2.31	0.34	121.0	3.09	65.0	9.7	445
11.4	2.63	0.41	133.0	3.63	81.0	12.6	460
13.0	3.00	0.41	150.0	4.09	136.0	18.7	510
11.0	1.10	0.37	106.0	3.79	30.0	10.0	438
13.0	2.66	0.38	139.5	3.73	130.0	18.6	?
11.0	2.75	0.42	147.0	4.20	90.0	13.8	500
?	0.79	0.40	90.7	3.66	30.0	15.0	445
13.5	2.59	0.37	158.0	4.53	60.0	9.0	580
13.3	2.26	0.37	118.0	3.15	113.0	18.5	518
?	?	?	138.0	3.24	?	?	474
11.0	2.79	0.41	149.0	4.19	?	?	472
13.0	2.30	0.41	124.5	3.50	21.0	3.7	524
15.0	4.43	0.51	136.5	3.25	130.0	15.1	432
15.0	2.99	0.47	125.0	3.35	80.0	12.4	465
17.0	3.60	0.60	136.0	3.88	90.0	15.0	530
15.0	3.60	0.60	136.0	3.88	80.0	13.3	500

It will be observed that the ratio between the useful weight and the total weight which formerly was hardly .30, now reaches .42. For *obus à mitraille* this ratio reaches even .60. This indeed is one of the chief advantages of this kind of projectile.

The foregoing table also shows that the use of shrapnel having a base charge is becoming more and more general.

As regards the weight of the bullet, it is generally 13 grammes (200 grains) with a tendency downwards to 11 grammes (170 grains).

Penetrating power.—The penetrating power of a bullet depends on the energy at the moment of impact. To stop a living objective, man or beast, very little energy is required. According to experiments made in Germany a lead bullet weighing 13 grammes (200 grains) with a velocity of 110 m. (360 feet) and consequently having an energy of 8 kg. (58 foot-pounds), is sufficient to stop a man. For a bullet of 11 grammes (170 grains), a velocity of 120 m. (394 feet) is required; for one of 15 grammes (231 grains) 103 m. (338 feet) is sufficient.

For a horse the energy of impact must be 19 kg. (137 foot-pounds), which corresponds to a velocity of 184 m. (604 feet) for an 11 gramme (170 grain) bullet, and 169 m. (554 feet) for a 51 gramme (231 grains) bullet.

The velocity of the bullets on impact depends on their velocity at the instant of the burst, and the interval between the instant of burst and that of impact. This interval is of great importance, especially as light balls lose their velocity more quickly than heavy ones. Very dense bullets have a considerable advantage over others, and for this reason General Wille has proposed tungsten for shrapnel bullets. This metal has a density of about 17, while hardened lead is but 9,5; but unfortunately in the present state of science, tungsten can be obtained only by costly processes, hence its price in the market is too high.

The important point therefore is not the total length of the sheaf, but rather the length of the useful part, that is, the part in which the bullets do execution. To show the influence of the weight of the bullet, General Rohne has drawn up the following table, which gives the length of the sheaf for different ranges.

From this it will be seen that the reduction in the weight of the bullet to 11 grammes (170 grains), has diminished very markedly the length of the useful part of the field shrapnel in *Germany*.

Dispersion of the Balls.—To determine the manner in which the balls spread after the bursting, and hence to understand how the

Ranges.	Length of the Useful Part of the Sheaf.			
	Shrapnel, model 1882. Wt. of ball 13 grm.		Shrapnel, model 1891. Wt. of ball 11 grm.	
	men	horses	men	horses
m.	m.	m.	m.	m.
1000	400	229	282	179
2000	344	183	249	138
3000	301	133	206	97
3500	279	105	195	84
4000	"	"	178	68
4500	"	"	161	55

shape of the cone of dispersion varies in different kinds of shrapnel, it must be borne in mind that the velocity of a ball at the moment of bursting may be regarded as the resultant of two other velocities; one parallel to the tangent to the trajectory, the other perpendicular to this tangent. The first, which might be called the longitudinal velocity, is equal to the remaining velocity of the shrapnel, slightly increased or diminished according to the position of the charge in the projectile; the second, which we will call the lateral velocity, depends both on the velocity of rotation of the projectile and the velocity of dispersion due to the internal charge.

These considerations are evidently not rigorously true, but they are sufficiently approximate for practice.

Upon the relative value of these two velocities will depend the magnitude of the angle of opening. If the longitudinal velocity is large relatively to the lateral velocity, the sheaf will be narrow and will have a sufficient density over a great length; in the contrary case, the sheaf will be broad and its density will rapidly diminish.

In studying the shrapnel cone of dispersion, we mark in general two suppositions. We assume that the sheaf has the shape of a right cone with a circular base, having its apex at the point of bursting and its axis along the tangent to the trajectory at that point. We also assume that the balls are uniformly distributed in the interior of this cone. There is no reason why we should not accept these two hypotheses, which facilitate a comparison between projectiles of different construction.

This being the case, let us denote the angle of opening of the cone by a, the longitudinal velocity along the tangent by V_l, and the lateral velocity by V_1. We will then have

$$\tan \tfrac{1}{2} a = \frac{V_1}{V_t};$$

but V_1 is the resultant of two velocities; one, the centrifugal velocity due to the rotation of the projectile around its axis of figure; the other, the velocity of dispersion due to the charge. These two component velocities are perpendicular to each other.

If we call the initial velocity V_0, and the final angle of inclination of the grooves i, the velocity of rotation at the muzzle of a point situated on the surface of the projectile will be equal to $V_0 \tan i$. We can assume without any great error that this velocity remains constant during the entire flight of the projectile. The velocity due to the dispersive action of the charge we can only obtain from trial; let us call it however for the time u.

We then have;

$$V_1 = \sqrt{(V_0 \tan i)^2 + u^2}$$

and consequently

$$\tan \tfrac{1}{2} a = \sqrt{\frac{V_0^2 \tan^2 i + u^2}{V_t^2}}$$

The angle of opening being thus known, it is easy to form some idea of the dispersion of the balls at a given interval from bursting, and consequently, of the effect of the shrapnel. It is plain that all the fragments are contained in a circle obtained by cutting the cone by a plane perpendicular to its axis. If D is the distance of this plane from the apex of the cone, and N the number of the balls, the density of the cone, that is the number of the balls contained in a square meter, is:

$$\frac{N}{\pi D^2 \tan^2 \tfrac{1}{2} a},$$

a being the angle of opening for the range considered.

This formula permits us to compare *a priori* the efficiency of different projectiles, since the probability of hitting a target of limited extent depends on the density.

Dimensions of the target.—It is not necessary to discuss this part of the question at length, for it is evident that the larger the objective the more risk it runs of being hit when exposed to artillery fire. This holds true whatever be the nature of the shrapnel. Yet it is also evident that the various objectives against which artillery will have to fire are not all of equal importance or of equal vulnerability. Of these many objectives, it is important to know which will be most frequently exposed to field artillery, in order to find that species of shrapnel which will give the maximum effect against this objective.

It is in this connection that the dimensions of the objective must enter into account in the study of field shrapnel. We will see presently what the ideas of General Rohne are on this point.

Flatness of Trajectory.—We will likewise limit ourselves to simply pointing out the importance of flatness of trajectory in considering the effectiveness of shrapnel firing. The flatter the trajectory, the longer is the zone covered. To obtain this result, we must not only increase the initial velocity but also the weight of the projectile per unit of cross section, in order to have it keep up its velocity. If the shrapnel does keep up its velocity well, the trajectory will be flat and the sheaf will be long even at long ranges. With a long sheaf, it is possible to produce some effect even at fairly long ranges, when on account of an error in elevation the fire is too short and the mean interval from bursting too great. This is the more important since field artillery is not yet in possession of any reliable and practical means for measuring the range.

MEANS OF INCREASING THE EFFICIENCY OF SHRAPNEL.

We have now become acquainted with the factors which affect the efficiency of shrapnel. It remains to be seen if we can deduce from what precedes some practical conclusion and design a new projectile better adapted to its purpose than those now in service. This projectile being clearly defined, it will not be difficult to calculate the elements of the piece to fire it, and in this way solve the question of the cannon of the future.

Examining again the elements that affect the efficiency of shrapnel, General Rohne remarks correctly that increasing the number of balls is the most certain means of increasing the efficiency of the projectile. The superiority of heavy projectiles is due chiefly to the greater number of balls that they contain This increase can be secured in three different ways: first, by increasing the weight of the projectile; second, by diminishing the weight of each ball; third, by modifying the construction of the projectile.

The first of these we must reject at once since it tends to increase the weight of the piece, and consequently to make the whole system too heavy. It would be dangerous to have a heavier field piece than the present German cannon.* Hence we must give to the new shrapnel a weight not differing much from that of the regulation German shrapnel, or a maximum of 7.5 kg.

* This weight is 2005 kg. (44.11 pounds) for the piece with entire equipment.

(16.5 pounds). It is to be observed that this maximum is greater than the weight of most of the shrapnel of to-day.

The reduction of the weight of the balls means a diminution in their penetrating power. To compensate for this, we must increase their velocity.

The Germans in reducing the weight of their shrapnel bullet from 13 to 11 grammes (200 to 170 grains) have diminished the length of the zone covered by the sheaf. It might be maintained that it is not the loss of energy in the balls which really limits the length of the destructive zone but rather the diminution of the density of the sheaf. Thus, for example, for the German shrapnel, model 1891, at 2,000 m. (2,187 yards) the balls are effective to 250 m. (275 yards) from the point of burst, but at this distance the density of the sheaf is only 104; there is then not more than one ball for 25 square meters of vertical surface. Under these conditions a line of skirmishers lying down 0.8 m. apart would receive but 0.61 hit.

The diminution of the density of the sheaf will be compensated for by firing a greater number of projectiles, whereas it is impossible to make up for the loss of energy in the balls.

There remains therefor as a single means to select such a mode of construction as will make the useful weight, that is the total weight of the balls as great as possible. General Rohne thinks that a shrapnel with a base charge, in which the useful weight equals .41 of the weight of the projectile answers the question, and moreover this projectile is easy to manufacture in the present state of science.

A shrapnel of this description with an initial velocity of from 500 to 600 m. (1,640 to 1,970 feet) will have a very long cone, but the opening of the cone will be kept within suitable limits if the final twist of the grooves is not made too great.

From what we have now established, and supposing the weight of the ball not to be less than 11 grammes (170 grains), we can say:

A shrapnel of	7.500	kg. would contain	280	balls
"	7.250	"	270	"
"	7.000	"	261	"
"	6.750	"	252	"

We shall see presently which of these projectiles is preferable.

In order that the sheaf may be sufficiently dense, the angle of opening must not be too large; on the other hand, if it is too small the effect will be too limited. If the angle of opening is reduced, the trajectory must be flattened in order that the beaten

zone may not be too small at long ranges. In the German shrapnel, model 1891, the length of the destructive zone of the sheaf decreases very fast above 3,000 m. (3,280 yards) because at this distance the semi-angle of opening is almost equal to the angle of fall.

Summing up, field shrapnel, according to General Rohne, should possess the following qualities:

1. Contain between 250 and 280 balls.
2. Have a narrow cone of burst.
3. Possess a high initial velocity.
4. Have a great weight for unit of cross-section.

APPLICATION TO THE STUDY OF THE CANNON OF THE FUTURE.

We can approach this problem in two ways. In every system of field artillery there are two principal elements to be considered, efficiency and mobility. These two elements up to a certain point are contradictory, and according as we lay stress on one or the other, we arrive at distinct solutions of the problem. We will examine the question from each point of view.

FIELD PIECE HAVING AN EFFICIENCY AS HIGH AS POSSIBLE WITH SUFFICIENT MOBILITY.

To fix the conditions for forming a new system of artillery, General Rohne premises that the artillery contest will occur between 2,500 and 3,000 m. He then lays down the following characteristics as essential to the cannon sought:

1. The angle of opening of the cone at 2,500 m. should not be less than 18°, in order that with an interval from bursting of 50 m., the sheaf should reach with certainty at least one piece of the enemy's artillery. The normal interval between two pieces in a battery is 16 m.; with an angle of 18°, the diameter of the sheaf at 50 m. from the point of bursting is exactly equal to 16 m.

This interval from the point of burst of 50 m. is not chosen arbitrarily. It is the mean interval from bursting in a regulation fire. In Germany the fuses are graduated so that the bursting when normal will occur at 50 m. this side the point for which the gun is laid. A fire at 2000 m. under regular conditions will have a mean point of burst at 1,950 m.

2. For a normal interval from bursting (50 m. under German rules) the density of the sheaf at 2,500 m. should be sufficient with a single projectile to kill or seriously wound half the cannoneers at one piece. Supposing that half the cannoneers face to the front, and the others to a flank, General Rohne estimates

the vulnerable surface at .4 square m.; the density of the sheaf should therefore be at least 1.25. But since a circle of 16 m. diameter has a superficial area of 200 square m., it follows that the shrapnel will contain 250 balls.

3. Finally at 3,500 m. (3,830 yards) the angle of fall should not be greater than half the angle of opening. Starting with these data and supposing the ball to weigh 11 grammes (170 grains), and the useful weight to be .41 of the total weight, we find for the weight of the shrapnel 6.7 kg. (14.74 pounds). If the weight of the projectile were increased to 7.5 kg,, (16.5 pounds) the number of balls could be increased the 280. This second projectile would have with an angle of opening of 20°, as dense a sheaf as one of 6.7 kg. with an angle of opening of 18°.

The initial velocity is deduced from the work we mean to impose on the piece. Fixing this work at 275 kgm. per kilogram of the weight of the piece (about 900 foot-pounds per pound), which is in no ways too large, and fixing the weight of the piece at 420 kg. (924 pounds), the initial velocity would be 580 m. (1,900 feet) for shrapnel of 6.7 kg. (14.74 pounds) and 550 m. (1,800 feet) for that of 7.5 kg. (16.5 pounds.)

Supposing that the projectile weighs four times as much as the solid shot of the same caliber, we obtain for the caliber respectively 77 mm. (3.03 inches) and 80 mm. (3.15 inches).

General Rohne fixes the final twist of the grooves at 6°; then supposing that the bursting charge imparts to the balls an additional velocity of 50 m. (164 feet) along the tangent and 20 m. (66 feet) perpendicular to the tangent, he constructs the following table, containing the principal data for firing these two cannon:

Data of Firing.	SHRAPNEL OF 6.700 kg (14.74 lbs). Caliber 77 mm. (3.03 in.)					
Range . . . . m	0	2000	2500	3000	3500	4000
Remaining velocity . . m	580	364	314	293	279	264
Angle of elevation . . deg	0	2° 34′	3° 30′	4° 38′	5° 56′	7° 19′
Angle of fall . . . . deg	0	3° 34′	5° 11′	7° 4′	9° 23′	11° 49′
Angle of cone . . . . deg	11° 38′	17° 38′	20°	21° 11′	22° 4′	23° 8′

Data of Firing.	SHRAPNEL OF 7.500 kg. Caliber 80 mm. (3.15 in.)					
Range . . . . m	0	2000	2500	3000	3500	4000
Remaining velocity . . m	550	336	309	291	279	264
Angle of elevation . . deg	0	2° 45′	3° 45′	4° 56′	6° 41′	7° 49′
Angle of fall . . . . . deg	0	3° 45′	5° 30′	7° 26′	9° 41′	12° 11′
Angle of cone . . . . deg	11° 38′	18°	19° 23′	20° 15′	21° 15′	22°

This table shows that for the light projectile the angle of opening is slightly greater than necessary, while on the contrary with the heavier projectile the density of the sheaf slightly exceeds the value fixed upon; but at 3,500 m. the angle of fall is less than half the angle of opening.

The figures of this table are only valuable relatively, since they are based on calculation, and not on experiment; nevertheless they show very clearly the effect of increasing the weight of the projectile and the initial velocity.

There still remains the question of the carriage, for as has already been stated, when we attempt to increase the efficiency of field artillery we are obliged to increase the resistance of the carriage to render it capable of supporting the extra work imposed upon it, and consequently to give it a weight incompatible with field service.

The work of recoil would be as high as 2,060 kgm. (14,900 foot pounds) for the cannon of 77 mm. (3.03 inches) caliber, and 2,280 kgm. (16,470 foot-pounds) for that of 89 mm. (3.15 inches). Now this work is only 1,690 kgm. (12,225 foot-pounds) in the German cannon, model 73-88, which weighs 420 kg. (924 pounds) and fires a projectile of 8.15 kg. (17.93 pounds) at a velocity of 419 m. (1,375 feet) with a charge of 1,500 grm. (3.3 pounds) of black powder. The carriage of this piece weighs 505 kg. (1,111 pounds); the work imposed upon it is therefore only 3.34 kgm. per kg. of the weight of the carriage (or 11 foot-pounds per pound). In order that the carriages of the pieces proposed may not be subjected to greater strain than this, they should weigh respectively 617 kg. (1,357 pounds) for the 77 mm. (3.03) piece, and 683 kg. (1,502 pounds) for the 80 mm. (3.15 inches).

CANNON HAVING SUFFICIENT EFFICIENCY AND THE MAXIMUM MOBILITY.

We will now take up the second part of the problem, and first of all let us define what we are to understand by sufficient efficiency. General Rohne thinks that the gun sought for will have sufficient efficiency, if at 2,500 m. (2735 yards) a shrapnel fired against a battery will give as many hits as the shrapnel model 1882 fired in the cannon of model 1873. He selects the shrapnel model 1882 because its effects are somewhat greater than those of the shrapnel model 1891.

But this condition is not enough. We must add to this the condition laid down above that at 3,000 m. (3,280 yards) the angle of fall will be less than half the angle of opening of the

sheaf and that at 2,500 yards (2,735 yards) this angle of opening shall be 18°.

This last condition necessarily implies a reduction in the weight of the projectile. The shrapnel model 1882 has an angle of opening at 2,500 m. (2,735 yards) of 22° 5', and gives 300 balls or fragments; consequently the number of balls and fragments from the new projectile should be equal to:

$$300 \frac{\tan 9^\circ}{\tan 11^\circ 2' 30''} = 240.$$

This number multiplied by 11 grm. and divided by .41 will give the total weight of the projectile, or 6.43 kg. (14.15 pounds).

On the other hand if the weight, 6.43 kg. (14.15 pounds), is a minimum, that of 7.5 kg. (16.5 pounds) is a maximum, since by going above this, we will obtain too great a weight for the entire system.

To determine the initial velocity, it is necessary to fix the amount of work to which the carriage is to be subjected. The author takes for this the same amount as for the carriage, model 73-88, or 1,690 kgm. (12,225 foot-pounds), and from this he deduces for the shrapnel weighing 6.43 kg. (14.15 pounds) a velocity of 560 m. (1,840 feet) and for that of 7.5 kg. (16.5 pounds) a velocity of 560 m. (1,640 feet).

He determines the calibers by supposing that the shrapnel weighs three and a half times as much as the solid shot of the same caliber. This gives calibers of 79 mm. (3.11 inches) and 84 mm. (3.31 inches). Here we can reduce the weight per unit of cross-section since the initial velocity is less than in the preceding case.

Supposing now that the final twist of the grooves is 6° and that the bursting charge imparts to the balls the same additional velocity as before, we are in a position to calculate all the ballistic data of the two pieces in question.

We will not give the results of this calculation since General Rohne did not find them satisfactory.

The projectile of 7.5 kg. (16.5 pounds) appears too heavy to him; that of 6.43 (14.15 pounds) too light and too difficult to arrange in its parts. He doubtless fears that the internal charge of this shrapnel is not sufficient to render its point of bursting clearly visible. However this may be, the true solution in his view consists in taking a mean course by adopting 7 kg. (15.4 pounds) for the weight of the projectile, 480 m. (1,575 feet) for the initial velocity and 81 mm. (3.2 inches) for the caliber.

Under these conditions, the properties of this piece will be as shown in the following table:

Velocity . . . . . . m.	480	300	282	268	255	243
Range . . . . m.	0	2000	2500	3000	3500	4000
Angle of elevation, deg.	0°	3° 41′	4° 56′	6° 26′	8° 7′	9° 52′
Angle of fall . . . deg.	0°	5° 0′	7° 0′	9° 19′	11° 49′	14° 37′
Opening of cone deg.	11° 40′	17° 40′	18° 30′	19° 23′	20° 4′	21° 0′

To show the effects of this new shrapnel, General Rohne has constructed the following table, taking 50 m. (55 yards) as the interval from bursting, and assuming a continuous vertical target 1 meter high, divided into sections half a meter wide:

Range.	Shrap., Base Charge.			Shrapnel Mod. 1882.			Shrapnel Mod. 1891.		
	Per round.		Zone covered.	Per round.		Zone covered.	Per round.		Zone covered.
	hits.	Sections hit.		hits.	Sections hit.		hits.	Sections hit.	
m			m			m			m
2000	21.7	15.1	295	20.7	16.0	344	20.1	16.2	249
2500	20.8	15.9	289	19.3	15.5	325	18.7	16.0	228
3000	19.7	15.1	283	18.0	14.9	301	17.5	14.5	206
3500	19.0	14.9	276	16.8	14.1	279	16.5	13.9	195
4000	18.2	14.4	267	"	"	"	15.6	13.0	178

It will be noticed that the shrapnel, model 1882, has an advantage in the extent of the zone covered, but the shrapnel with the charge in rear is superior to that of model 1891, above 2,000 m. General Rohne has the following observations in this connection:

"The 7 kg. (15.4 pounds) shrapnel with charge in rear will compare favorably with the shrapnel model 1882 in efficiency, and will surpass in this the shrapnel model 1891. This superiority will increase as the interval from bursting increases. The number of hits is inversely proportional to the square of the interval from bursting, but the number of vertical sections hit decreases more slowly for the base charge shrapnel. Thus at 2,500 m., with an interval from bursting of 100 m., the 7 kg. shrapnel gives 9.6 vertical sections hit per round; the shrapnel model 1882, gives 9.0; and the shrapnel model 1891, only 8.9. The greater the interval from bursting, the more pronounced does the superiority of the base shrapnel become, especially at long ranges because then ths flatness of the trajectory and the velocity of the balls have a preponderating value."

The base charge shrapnel at short ranges, when the interval from bursting is small, will not reach so many files on account of

its narrow cone as the shrapnel of model 1881. This is however but a slight defect, amply compensated by the advantage of having a longer destructive zone.

It must be always borne in mind that in action errors in elevation will frequently occur. For one reason or another, the battery commander will not know the exact elevation required to attain the target. He will have to resort to establishing a fork, sometimes quite large, say 200 m., or perhaps 400 m., and will then have to fire tentatively between these limits.

To completely determine the piece its weight must be fixed. This can be found in various ways according to our views of the state of science, for all depends on the amount of work we mean that the metal must bear. In the present instance the total work on the gun is 82,300 kgm. (595,276 foot-pounds). Assuming that 200 kgm. per kilogram (658 foot-pounds per pound) is a reasonable estimate, we have 411 kg. (904 pounds) for the weight of the piece. It is to be noted in this connection that in the Sotomayor cannon model 1890, the work per kg. is 275 kgm. (900 ft.-pounds per pound). Captain Moch in his paper on the cannon of the future uses 350 kgm., and General Wille 530 kgm. Thus it will be seen that the requirements of General Rohne are very moderate.

But the lighter the cannon, the more the recoil tells on the carriage, which must be made heavier to offer sufficient resistance.

Fixing the weight of the piece at 415 kg. (913 pounds) and the weight of the charge at .600 kg. (1.32 pounds), the work of recoil will be 1,510 kgm. (10,922 foot-pounds). The present field carriage works well with 3.34 kgm. per kg. (or 11 foot-pounds per pound). If it is not desirable to exceed this figure, we obtain 452 kg. (994 pounds) as the weight of the carriage.

There is nothing unreasonable in this and General Rohne is indeed very conservative, for carriages have been required to stand a good deal more than this. Hotchkiss goes as high as 3.79; General Wille asks for 7.9.

In calculating the weight of the limber, General Rohne assumes that it will transport the same number of rounds as that of the cannon model 1873, and that the charge of the piece will be contained in a metallic case weighing at most .800 kg. (1.75 pounds). This gives 8.4 kg. (18.5 pounds) for the weight of a complete cartridge (projectile and charge) or 269 kg. for the 32 rounds transported by the limber.

As the limber chest will be smaller than the present limber chest, we can probably reduce the total weight of the limber to

830 kg. (1,826 pounds), which gives 1,730 kg. (3,806 pounds) as the weight of the entire carriage.

"It does not appear reasonable to me, General Rohne adds, to go below this weight, for it seems to me impossible to construct a caisson carrying 77 rounds (32 in limber and 45 in rear carriage) and weighing less than 1,900 kg. (4,180 pounds). Moch assumes in his calculations that a caisson can be made in which the weight of the ammunition will be from 40 to 50 per cent of the total weight. If this were true the weight of the caisson would be as low as 1,618 or even 1,294 kg.; but even in this case, I would prefer to hold to the weight of 1,730 kg. and increase the number of rounds transported from 76 to 80, or even to 100."

Such in brief are the ideas advanced by General Rohne in his study of field shrapnel. Although he states that he is not presenting a new piece, nevertheless he has laid down the principal qualities which the cannon of the future must possess. The General is very conservative; his ideas seem even timid compared with those of his predecessor, General Wille, but they have the immense advantage of being a good deal more practical, and of being based on rational assumptions.

What seems particularly valuable in this discussion is the tendency to lengthen the destructive zone of field projectiles, and to reduce the weight of the material so as to increase the mobility. But it is important to observe that the author has not been led into exaggeration here. The weight which he prefers is 1,730 kg. (3,806 pounds) which, though considerably less than the present weight, yet permits of an arrangement of the whole system on a sound basis. The General in this is clearly distinct from certain of his predecessors who demand a piece so light that it is almost useless.

We will make one more observation before closing. In reading the work of General Rohne, we are struck by the silence of the author on the question of rapid-fire guns, although this is now the uppermost question in all European countries. This silence is evidently intentional; there is hardly a reference to an increase in the rapidity of fire, although incidentally he favors the adoption of a metallic case. We are not acquainted with General Rohne's grounds for this omission, but the fact is nevertheless significant.

C. JEANNEL,
Major of Artillery.

[Translated by Lieutenant George Blakely, 2nd Artillery.]

SEA-COAST ARTILLERY AND SUBMARINE MINE DEFENSE.

Mittheilungen über Gegenstaende des Artillerie und Genie-Wesens.

The purpose of the following remarks is to build up, on tactical and technical foundations, a theory for calculating the artillery equipment required for modern coast fortifications, with special reference to the influence exerted upon the solution of this question by the submarine mine defense.

The choice of guns depends first of all upon the tasks laid upon the coast artillery during the various stages of defense. These will be concisely summarized as follows:

The most important function of coast artillery is to keep the large armored ships of the attacking fighting fleet as far as possible from the coast fortifications in order to prevent them, while battering the forts, from bombarding the inner harbor at the same time.

Its next duty, which is somewhat similar, is to prevent the fighting fleet from *approaching* the entrance to the harbor and then to prevent it from *forcing* an entrance.

To assist the coast artillery in performing this last part of its task, obstacles are used composed of submarine mines; which, according to the views prevailing in naval circles, should be planted in two absolutely distinct and independent zones.

The first of these zones, planted well in advance of the harbor entrance and the coast fortifications, should span the entrance in a well extended arc.

The second, a more retired zone, should be on the line of the extreme points of the harbor entrance and is intended to obstruct the entrance proper.

The first zone also, of course, assists in preventing approach to the harbor entrance; and the second zone assists in preventing the entrance from being forced by battleships.

Both lines of obstacles fulfill their purpose against the large armored ships only in a certain sense; but not at all against torpedo flotillas which can remove the outer line.

Both lines can be passed by torpedo flotillas as is proved by the most recent war experience, the attack on Wei-hai-Wei.

Hence it is the second important duty of coast artillery to prevent not only the large battleships but also the other, smaller

vessels of the attacking fleet first, from approaching both of these zones of obstacles and second, from forcing a passage through them.

The fulfillment of both these tasks demands:

1. Destruction of floating and maneuvering capabilities of the large battleships at ordinary battle distances; which, considering the present resistance of armor, can be attained only by large, heavy cannon with great powers of penetration;

2. Destruction of torpedo boats and catchers and other small members of the fleet, having little or no armored strength but possessing, just on account of their build, a speed as great as 30 sea miles an hour and an extraordinary facility in maneuvering; which destruction demands little power of penetration but the highest possible rapidity of fire.

Hence the work of defense demands heavy long range guns and light quick-fire cannon.

Let us now consider the heavy long range guns:

In modern battleships the most vital parts are protected by side armor of compound or steel plates running in thickness up to 550 mm. (21″.65); and nickel steel is now being used, which is still stronger. The other parts of the ship are protected by a steel deck below the water line from 60 mm. to 80 mm. (2″.36 to 3″.15) thick.

Since the power of the great guns of a modern battleship has of late reached a high degree, the fight should be begun at great distances. In order to oppose them with any chance of success and in order to penetrate the protective side armor at these excessive battle ranges, the calibers of the heavy coast guns should be large which will, it is true, involve, but unavoidably, tactical disadvantages, such as slowness of fire, immobility, etc.

In order to comply with these important tactical demands and yet achieve increased results at long distances, the work to be done by guns is divided into two parts, horizontal and vertical; and high power, flat trajectory cannon are assisted by mortars or howitzers of large caliber, specially intended for fighting at great distances.

It is evident that, if both kinds of guns are really to complement each other, the choice of calibers must be carefully considered and that certain guiding motives must regulate this choice. The most important point to be considered, in connection with the tasks which coast cannon must fulfill, is the interdependence of the cannon on the submarine mine defense which exerts an important influence on the question.

The following remarks will show that a very definite relation exists between these two branches of defense, from which can be deduced not only the conditions determining the question of caliber, but also those determining the location of the submarine obstructions.

The idea that the foremost line of submarine mines must be pushed forward as far as possible in front of the harbor entrance, say as much as 3000 meters (1.86 miles), is based on the principle that coast artillery is not, of itself, sufficiently active to be able to stop an energetic enemy for long; and that it can produce satisfactory results only when the advance of the enemy is hindered by an obstacle in the foreground.

On the other hand submarine mines are, of themselves, completely incapable of offensive action because, if not supplemented by other defense, they can easily be removed and a safe passage through them be effected. Hence, submarine mines must be defended.

Hence, these two means of defense (guns and mines) are not independent of each other but stand in the closest reciprocal relation to each other. Where mines are to be planted the most advantageous artillery support must be provided.

The correctness of this proposition follows from the universally true ground principle of all fortification that an obstacle is only properly effective when it holds the enemy in the place best suited for hitting him with the projectiles of the defense.

As an example of this, from naval history, take the fight for the entrance to New Orleans where passage was opposed by more than 60 cannon in Forts Gains and Morgan as well as by a system of submarine mines planted in the channel but having no relation to the land guns.

Not bothering himself much about the cannon, Farragut ordered the channel to be forced and succeeded, without having his wooden ships much damaged by the artillery of the defenders.

Since the mines now in use do not vary in their effects wherever they may be placed (*i. e.* they are not weapons of varying range, for instance) it follows that, locally, they may, within certain limits, be subordinate to the requirements of the best disposition for the artillery; but only *within certain limits*, for they must always be laid in front of a harbor entrance. The *extreme* limit of the mines used for defense determines the caliber of the coast cannon; (that is, the artillery is here subordinate to the mines); within this zone the mines are planted with regard to the requirements of the artillery.

This is, in brief, the relation which exists between coast artillery and submarine mine obstructions and it only remains to work out the realization of this relation.

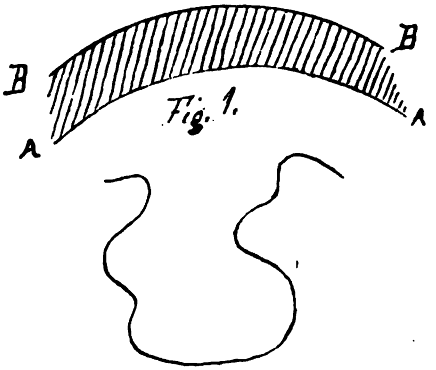


Fig. 1.

The effect of horizontal (flat trajectory) fire diminishes as ranges increase. Hence there must exist, for the cannon used in coast forts, a line *BB* (Fig. 1) more or less distant, marking the limit within which these cannon can pierce the thickest side armor now used in shipbuilding. An armored ship between this line and the coast should be in very great danger; and this gives the maximum limit of the effective area of the flat trajectory guns.

In a similar manner the high trajectory guns, whose effect increases with the range on account of the increase in powder charge, have an interior limit of their effective area; that is, there exists a line *AA* which marks the minimum distance at which the energy of impact of mortars and howitzers is sufficient to pierce the armored decks now in use. Hence, the use of vertical fire against objects within this line will be without decisive effect.

From the overlapping of these two "effective areas" results a zone *AB* of greater or less width which may very properly be termed the "zone of most favorable artillery fire"; because within its limits must occur the effective results of both vertical and horizontal fire against all armored ships; also because both those kinds of fire can be used simultaneously and with good effect against any war ship moving with this zone.

Within this zone *AB* must lie the outer or most advanced line of submarine obstacles; and since this location is practically unavoidable and invariable it determines, within certain limits, the calibers of the coast cannon.

By such an arrangement, a zone of defense is obtained, so extraordinarily strong as, perhaps with justice, to be open to the charge that, in case it fails, the fate of the harbor will be practically decided.

To this it may be replied that such a zone of defense is so very difficult to capture, and then only with such great losses, that the possibility of its capture can be hoped for only by a greatly superior hostile force.

If these two methods of defense are made independent of each other then, of course, two lines must be prepared each single one of which will, however, be comparatively easy to overcome. This is proved by the above mentioned example of New Orleans; and the recent example of Wei-hai-wei proves nothing to the contrary, because Admiral Ito, by his just conclusion that the weak land defenses could be easily captured by a landing force was able to dispense with forcing the channel by his battle fleet and so avoided the sacrifice of a ship.

Hence the above described arrangement of the means of defense should be adhered to and a further development of the relation existing between coast artillery and submarine mine defense will enable the question of calibers to be deduced from the necessities of the said arrangement.

First of all it is clear that the outermost line of mines will be pushed as far to the front as possible in order to hold the attacking fleet as far as possible from the harbor entrance. This requirement demands that the maximum radius of the "sphere of effect" of the high power (flat trajectory) guns shall be as long as possible and necessitates the use of large calibers. This requirement is, however, antithetic to the requirement of rapidity of fire. Hence these two requirements must be reconciled, as far as possible, in the choice of high power guns.

The area within which battleships will be seriously threatened and endangered by coast artillery should be as large as possible. Hence a wide zone of the most favorable artillery fire should be worked out and this can be attained only when the minimum radius of the "sphere of effect" of the high trajectory guns is very small.

Hence the conditions which govern the choice of coast guns are

1. Large maximum radius for the "sphere of effect" of the flat trajectory guns with a corresponding rapidity in their fire.

2. The shortest possible minimum radius for the "sphere of effect" of high trajectory guns.

3. A distance of the mine obstacles of at least 2000 to 3000 metres (1.25 to 1.86 miles).

Since the question of high trajectory sea-coast guns has not yet been as completely solved as that of flat trajectory guns there is at present no great choice. Hence we will assume, for argument, the 28 cm. (11") Krupp sea-coast howitzer *l*/12 as the gun formerly best suited to existing conditions.

By using this really splendid gun we have as our minimum radius the distance of 2000 meters (1.25 miles) as the allowable minimum against the ordinary steel armored decks of battleships, from 60 mm. to 80 mm. thick (2".36 to 3".15), the charge of the howitzer being 10 kg. (22 lbs.). According to Krupp's firing table for this howitzer, an elevation of 63°.7 gives 2200 meters (1.36 miles) range. But by using 68° elevation a range of 2000 meters (1.25 miles) can be obtained.

Hence the interior radius of the outer mine defense zone may be taken as 2000 meters (1.25 miles). Since the extreme radius of this zone is determined by the maximum effective range of the flat trajectory guns, it follows that their sphere of effect must reach beyond 2000 meters (1.25 miles). Hence the cannon used in coast fortifications must be able at distances greater than 2000 meters (1.25 miles) to hit the armored ships of an attacking fleet in their most vital parts and with such effect as to jeopardize their floating and maneuvering qualities. But this is only possible when these cannon can pierce with a sufficient reserve of energy the greatest thickness of side or citadel and casemate armor used in shipbuilding.

Hence this armor thickness and material determine the power of penetration which must absolutely be had; and this power of penetration, taken in connection with the conditions already discussed, and demanded by the mine defense (as to what must be expected from the guns) determines the caliber.

Let us now consider the side armor most in use by the battleships of the great navies, using the table on the next page.

Thicker armor is found only on the following ships:

England,	*Sanspareil*	457 mm. = 17".992	Out of a fleet of 52 battleships.
	Nile, *Trafalgar*	507 mm. = 19".96	
France,	*Amiral Baudin*, *Formidable*, *Amiral Duperré*	550 mm. = 21".653	Out of a fleet of 25 battleships.

Italy, *Italia*	Turret armor	All old ships out of a fleet of 12 battleships.
Lepanto	480 mm. = 18″.898	
Dandolo	Side armor	
Duilio	550 mm. = 21″653	

Country.	Thickness of Side Armor most commonly in use.			
	Compound or Steel Plates.		Nickel Steel Plates.	
	mm.	inches.	mm.	inches.
Germany	400	15.75	300	11.81
England	456	17.9527	355	14.00
France	450	17.72	400	15.75
Italy	450	17.72	254	10.00
Russia	400—450	15.75 to 17.72	——	——

Hence for purposes of discussion we may very properly assume a compound or steel plate 460 mm. thick (18″.11) and take the destruction of such a plate as a foundation for calculating the needed power of penetration and hence determine the caliber required in our flat trajectory sea-coast cannon.

The steady improvement which has characterized Krupp's sea-coast cannon—as evidenced by the successive types C/80, C/87, C/89—authorizes us at once to assume C/89 as the latest and most complete construction of its kind.

The following table contains all desirable data for Krupp's sea-coast cannon C/89 of 24 cm. to 30.5 cm. (9″.449 to 12″). The data given for powers of penetration up to 2000 meters range (1.25 miles) are from the results obtained at the works; for greater ranges, are calculated.

It appears from this table, first of all, that guns 50 calibers long are to be preferred, for the purposes under discussion, to those 40 calibers long, because they admit of a smaller caliber and hence of a lighter projectile.

Comparison of two consecutive (in the table) guns of different calibers and different lengths shows that the effectiveness of both against armor is about the same; while the reduced weight of projectile, lighter powder charge and less weight of gun for the smaller caliber are advantages in obtaining rapidity of fire.

It also appears from the table that Krupp's 26 cm. (10″.236) coast cannon, 50 calibers long, fulfills the conditions previously established. The data given in the table show that its armor piercing shell *l*/3.5 will pierce compound or steel armor 460 mm. (18″.11) at distances, in round numbers, of 3200 meters (two

miles). Hence, in connection with the 28 cm. (11".024) coast howitzer, a zone 1200 meters wide (0.75 mile), for the planting of the submarine mine defense, is obtained, within which zone the entire effectiveness, both of howitzers and cannon, is combined against all classes of armored ships.

This in no wise prevents future progress in armor manufacture from being considered in our choice of equipment for sea-coast forts and so, in order to be on the safe side, our final choice might well rest on the more powerful 28 cm. (11".024) gun, 50 calibers long.

It must be acknowledged, however, that these two guns permit of none too far an advance in the front line of mine obstacles —and a long distance out may often be required for that line. But here the requirements of tactics step in and demand a corresponding rapidity of fire. Hence, at present, the 28 cm. gun must place the limits.

The particular sizes of guns which have now been deduced, by solving the question of caliber by considering the influence of the mine defense upon it, prescribe at once the proper location of the line of mine obstacles in the zone of most effective artillery fire.

Let us assume points, *ZZ* Fig. 2, on both sides of a harbor entrance, for middle points of artillery defenses. There will then

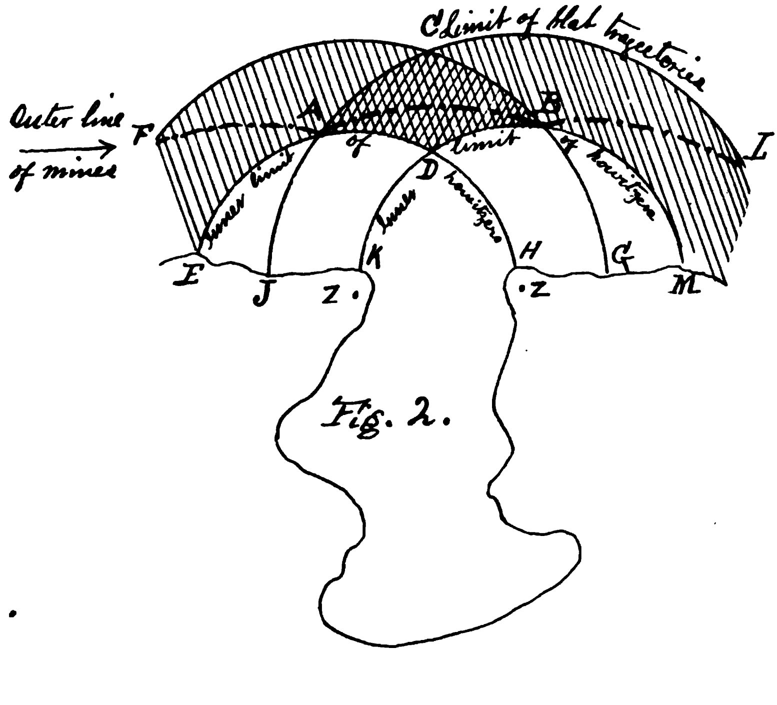


Fig. 2.

result, from our previous argument, two separate zones of effective artillery fire, *FGHE* and *JLMK*, which combine to form the particular zone for the mine defense *FCLMDE*.

It appears from the figure that the intersections of the exterior and interior limits bound a particular space *ACBD* within which all of the long range cannon, of both kinds (high and flat trajectory), from both shores of the harbor entrance, can produce their full effect upon all kinds of armored ships. This area, which lies inside of the area of "effective artillery fire", might be called the area of "most effective artillery fire".

It goes without saying, of course, that this latter area is to be utilized for the mine obstacles; and that portion of the entire line of mines which falls within this area would no doubt be planted approximately on a line similar in position and direction to *AB*. This would make the defense strongest across the probable line of an attempt at forcing entrance.

The line of mines should then be prolonged toward both sides in an intelligent manner, still within the zones in which the flat trajectory guns of the nearer side of the harbor and the high trajectory guns of the farther side will have their full destructive effect against battleships moving in those areas.

Summing up the previous remarks we have

1. Suitable long distance guns for modern coast forts are the 26 cm. to 28 cm. (10".236 to 11".024) Krupp sea-coast cannon *l*/50, C/89.

2. Suitable high trajectory guns are Krupp's 28 cm. (11".024) sea-coast howitzers *l*/12.

These cannon are capable of penetrating with sufficient surplus of energy and within the zone of submarine mine obstacles such compound or steel side and deck armor as is most used at present in shipbuilding.

These cannon will fulfill, however, only a part of the work we have heretofore outlined for the sea-coast artillery, namely, the fight against large battleships.

It remains to determine, concisely, those calibers which are best for fighting smaller and speedier vessels, that is, torpedo boats.

It is evident, that, on account of the light build of these boats, their mobility, facility of maneuvering and great speed, the effectiveness of guns used against them will depend less on power of penetration than on a high degree of rapidity of fire; hence, that only quick-fire guns are suitable.

What calibers then are necessary? In order to determine this we must consider the duties of torpedo boats in attacks on harbors.

At the commencement of an action, torpedo boats have the duty of reconnoitring and of removing the outer line of obstacles. While doing this the coast artillery should be able successfully to destroy them. Hence the equipment of coast forts must include quick-fire cannon which, at the ranges of the mine obstacles, can seriously imperil the buoyancy of torpedo boats of all kinds; that is, the projectiles of such guns must have sufficient energy, at ranges of 3000 to 4000 meters (1.86 to 2.48 miles), to pierce with certainty the thin steel hulls of these vessels. Hence, such guns take part in the defense of the mine obstacles.

For the purposes above indicated, Krupp's 8 to 9 cm. (3".15 to 3".543) quick-fire guns are excellent, because they combine great rapidity of fire with rather high power of penetration.

The exact figures against steel are:

Range.	Penetration.
At muzzle	118–214 mm. (4".6 to 8".4)
At 4000 m. (4300 yds.)	50–60 mm. (2" to 2".4)

which are quite sufficient for fighting torpedo catchers, torpedo boats and smaller vessels.

It will also be of great advantage against attempts at landing to use these guns, firing shrapnel.

In the later development of an action against a fortified harbor, it will become the duty of the torpedo flotilla to penetrate into the interior of the harbor, if only for a short time, in order suddenly to attack such fleet of the defenders as may be found there and inflict as great injury upon it as possible. This is intended to prepare the way for the subsequent forcing of the entrance and capture of the harbor by the battleships. If this attack of the torpedo flotilla succeeds, the channel will at once be cleared of its submarine mine obstacles.

These torpedo boats will endeavor to make the entrance as close to the shore as possible and with the greatest speed. In order to stop them, since the ranges of projectiles will now be very short, the requirements of the case demand less power of penetration and a much increased rapidity of fire.

These requirements are fulfilled by the Krupp 5 to 6 cm. (1".97 to 2".36) quick-fire guns which fire 20 shots per minute and even at ranges of 2000 m. (1.25 miles) have a power of penetraiion of 30 to 40 mm. (1".18 to 1".57) which is quite sufficient for the thin steel hulls of torpedo boats.

The work of these guns will be done at short range and inclu covering any "dead spaces" which might assist the efforts o landing party. Hence, they should be mounted as low as po ble, even on the shore or beach, and they will be quite secur they are mounted behind shields, say on Schumann's syst (Gruson).

SIGMUND MIELICHHOFFER,

Captain in the Austrian Fortress Artillery Regiment, No.

[Translated by Captain T. A. Bingham, Corps of Engineers, U. S. Army.]

RTIFICATIONS
S.

:ION.

ı the plans of our
:on was the defense
:ions of savages or
eeting of the pro-
ıd, on October 15,
vhich it was agreed
half the total ex-
t by the planters.
proportion to the
se wise resolutions
though from time
dignity of general
y carried out, nor
e outbreak of the
stle Island in the

ounding them was
there was always
occupation of the
ers, they at once
g the peninsula of
The guards at the
their occupation.
out without doubt
d before any other
f a foundation of
parapet of moder-
ırapet and on the
lug, while beyond
or passage through
number of guns
all howitzer type.
ay, but were kept

up so long as there was any danger to be feared from the Indians. With peace and the settlement of the country around Boston came indifference to the condition of the defenses. This continued until 1710, when the town voted to rebuild this defensive line. At this period Queen Anne's war was in progress, with no great credit to the British arms. Before this date rumors of the possibility of an attack by the French and Indians were rife, and extensive steps were taken to restore the decayed defensive works. In 1706 the sum of £1000 was voted for fortifications; and it was no doubt under this appropriation that the old lines on the Neck were rebuilt and strengthened. From that time until just before the beginning of the revolution nothing more was done in the way of an improvement of this military barrier.

This indifference to the military needs of the colony during the period of the control of the General Court, and the sudden and expensive rehabilitation of half ruined, half forgotten fortifications at the actual or seemingly imminent presence of the enemy, is an early evidence of one of the shiftless characteristics of our people to-day. Whether it is that we are endowed with an inexhaustible self-confidence—and the unstudied utterances of our legislators would lead us to think this—or that happy fate has pursued us with tireless good luck, one cannot say; but certain it is that there has been from the beginning of our history a total inappreciation of disastrous possibilities in operations of war in which we may be concerned, which exists even now, but on a far more serious scale.

Fort Hill.—Among the enemies which our colonists had to fear, the most to be dreaded would approach them from the sea. It was therefore with a view to meet the attacks of ships that the colony, on May 24, 1632, began the erection of the strong work on an eminence near the shore of the harbor, which from its position covered the passage from the outer bay. Under the compact already mentioned the money and labor were furnished, half by the company and half by the colonists, the men for the work being drawn from the towns of Boston, Charlestown, Roxbury and Dorchester. The records of this period show that great difficulty was experienced in getting the laborers, who exhibited the usual disinclination of volunteers for disagreeable work. At times, progress on the work almost ceased for want of men; then an outburst of wrath from the General Court and some stringent regulations concerning delinquents would drive the work ahead. But in spite of the persistent efforts of Governor Winthrop and his Council and the Court, matters progressed very slowly. In

1633 some guns were mounted; but the fort was not completed for a year or two after that. The exact character of this fort is not known, but from the slowness in building, apart from that caused by the constant strikes of the workmen, and the money spent on it, it must have been of considerable strength, though primitive in design.

As was usual, the fort went into gradual decay, spasmodic attempts being made to force the colonists to the work of repairs. When Andros took the reins of government, one of his first duties was a tour of his domain, with a careful eye for its defenses. In 1687 he ordered built a new fort on the hill, which consisted of a quadrangular work of four bastions, with a palisade and a house for the shelter of the garrison. It was at this place, then called Fort Andros, that Sir Edmund was surrounded by his Puritan subjects, who had insisted on their charter rights and whose courage rose to the rebellious point on learning of the overthrow of the home government to which Andros owed his power. The surrender took place without bloodshed, Andros making no resistance, and the warship lying near the wharf at South Battery struck its colors with equal promptness, though nothing more deadly was pointed at it than a resolution of the General Court.

From this time the Fort Hill fort was the center of but little general interest; and certainly nothing of military importance occurred there. It was used principally as a vantage point for bonfires and the burning of saluting powder, to which our solemn Puritans were very prone. In 1760 the place took fire, and in spite of efforts to withdraw the powder, much was abandoned, and the fort blew up, thus perishing in a truly martial manner. In this state it remained until after the evacuation of Boston by the British, when Washington ordered works to be erected on the hill; but in 1779 he caused the withdrawal of the heavy guns for his lines of defense on the Hudson. The fort was never again raised to its former glory; and in 1797, the pick and shovel began the work which has ended in the almost total disappearance of one of the best known ancient landmarks of Boston.

Merry's Point Battery.—In the general scheme for the defense of the bay side of the town was the fortification of the shores to prevent the approach of an enemy from the sea, and also to oppose his passsage into the Charles river. Particularly for this latter object was the erection, 1646, of a small battery at a point now known as North Battery Wharf. At that time this wharf, then known as Merry's wharf, stood nearly on the northeasterly point of the peninsula and overlooked the entrance of the inlet

which led to the Charles. The wharf was changed into a platform laid on a stone foundation and protected from the wash of the water by piles faced with heavy planks. At first but seven guns were mounted on it, but its power was subsequently increased, although at the time of the British occupation it was reported as in ruinous condition. This work was many times repaired and as many times allowed to fall into decay. In 1739 it was so weak as to call for immediate attention; and in the reconstruction it was lengthened by one hundred feet and broadened by forty feet. An engraved picture in the proceedings of the Historical Society of 1877 shows the North Battery as it was in 1760. A rude wall of stone at the end of a wharf pierced by embrasures, with small towers at the corners, illustrates the simplicity of the early ideas of forts in this period of colonial development. In 1789 it was dismantled and sold.

South Battery.—A battery called South Battery, of similar construction to the above, except instead of a breastwork of wood and stone it had a parapet of earth, was erected in 1666 by Major General John Leverett where Rowe's wharf now stands, and was intended as a supplementary work to the fort on the hill, with which it was connected by a road. It was commonly known as the Sconce, and owed its existence to the fears caused by the first Dutch war. Some years before this, in 1636, the General Court granted the town of Boston six pieces of ordnance and thirty pounds sterling to construct a battery at the Sconce; but this work was of the most primitive order. The best description of General Leverett's fortification is most vague. It is said to have been made of "whole timbers" filled in with stone and earth. At first it mounted nine guns, then thirteen, which were arranged to traverse over the entire water front; and in such a way that no gun masked the fire of any other. It was probably enlarged from time to time; for we find there, in 1743, thirty-five guns. It had the reputation of being the strongest work of its kind in the country. An illustration of it, made in 1740, shows a quadrangular work of stone with short-sided bastions, and in rear a a rude block house, probably used by the garrison as a barracks. It too was in a ruinous condition when the British took possession; and though subsequently repaired and occupied, it was finally, after the war, dismantled and sold.

The Barricado.—In 1673 a proposition was laid before the town to build a sea wall along the harbor front to prevent the fire ships of an enemy from destroying the wharves and warehouses. The town declined to undertake this project, but placed power in the

hands of the selectmen to grant lands and privileges to encourage private enterprise in this direction. The work was accordingly undertaken by forty-one citizens, whose contract called for the construction of a wall of wood or stone twenty-two feet at the bottom, twenty feet at the top and fifteen feet high; to have parapets for cannon and openings left for ships. Thus was conceived and begun one of the most absurd military structures of the age. When finally completed or nearly so, in 1681, it consisted of a line of embanked wharves, some 2200 feet from flank to flank, separated into five unequal parts by three intervals designed to permit the passage of ships to the inner waters enclosed by them. Owing to a deep bend in the shore at this period, the enclosed water was quite extensive, the whole thus constituting a sort of fortified mole. The parts were constructed of piles and planks like other wharves, except that the timbers were heavier, and parapets erected for barbette connon.

This very astonishing work, called "The Barricado," was accepted by the General Court in 1681, and became part of the town's defenses. It went through the process common to coast defenses in this country of alternate decay and reconstruction with long intervals between, until by March 1728, it had reached a sad state of ruin. No further attempts at reconstruction were made; and there being no fear of foreign attack, the value of the Barricado as a means of defense declined; and piece by piece as wharves were built, this great work disappeared, the last vestige of it being incorporated in Central Wharf in 1816. In the meantime it rotted slowly away, its dangerous capabilities exhibited in its character of a reef, and to its friends only.

Castle Island.—By far the most stupendous military work accomplished before the War of the Revolution was erected on a small island about half a mile east of Dorchester head, or what is now known as South Boston. The old name of Castle Island, which the place had at the very beginning has been almost forgotten in the official title of the present work, known as Fort Independence. The fortifying of this place was the outcome of a desire to better protect the harbor entrance. At first it was thought that Nantasket was a better location, but two or three very uncomfortable nights spent on that bleak headland by the governor and his council, and the usual coterie of preachers (nothing, not even military works, could be undertaken in those days without the approval of the pulpit) on their tour of inspection, impelled them to look for a location nearer home. Beyond these recommendations nothing was accomplished until 1634,

when the same committee of safety assembled at Castle Island, went through the usual pleasant outing, a habit still indulged in by the inspecting committees of our governing bodies, and sent to the General Court certain recommendations for the fortifications on Castle Island.

In the meantime, 1633, some one proposed to the General Court the construction of a "moving" (probably meant floating) fort, somewhat vaguely described as having or to have a length of 44 feet and a width of 21 feet. An appropriation of £144 and 1100 feet of four-inch plank was made for this deadly instrument of war, but it does not appear that the foolishness and eager parsimony of the General Court went so far as to enter on its construction.

Pursuant to the recommendations concerning Castle Island, work was begun there in March, 1634, and was continued industriously during that and the following year until there was completed a strong wooden platform for the mounting of guns, with a mid-parapet or wall in front. This was placed on the northeastern shore of the island overlooking the main channel, while on the summit and connected with the lower work by a plank way was a block house, placed so as to protect the battery. This first fort was in every way cheap and temporary. It soon fell into decay although constantly repaired, sometimes by the colony, but oftener by the volunteer work of individuals. A guard was established there at all times although the place must have been uninhabitable in many of the early years. The state of the fortifications finally became so desperate that the island was turned over to Captain Gibbons, its commandant, to let for pasturage. It was during this period of military weakness that the French adventurer La Tour appeared in the harbor (1643); and although he exhibited the greatest friendliness and amiability, his presence aroused the colonists to a knowledge of the ruinous condition of the defenses; and the incident undoubtedly prompted the authorities to rebuild the fortifications on Castle Island. The midwalls, or what was left of them, were soon replaced by heavy piles banked with earth. A few years saw them in turn decay and crumble, to be replaced by a structure three stories in height, made of brick, and mounting six sakers and three smaller guns. The building of the fort, undertaken after the visit of La Tour was the work of the various Bay towns. Money was contributed and the labor was done by such men as could be hired or forced to do their alloted share. The General Court exhibited its usual close economy, and in its large overbearing way, permitted the

several towns to do all the work, but reserved for itself the right to prescribe the government of the place and the control of the garrison. The garrison at this time was drawn from Boston, Charlestown, Dorchester and Roxbury, and consisted of one captain, one lieutenant, other officers and sixty-four men. In 1672 the Castle burned down, and at a time too, when the Dutch were growing dangerous.

The usual periodic scare, the only emotion capable of arousing patriotic military prudence, started once more the work of fortification in 1674, which continued with a rapidity in direct proportion to the imminence of danger until 1686. The new work was subsequently named Fort William and Mary in honor of the newly imported reigning family of England. This work consisted of a small fort mounting twenty-three guns, a lower battery, probably the old one reconstructed, mounting seven guns and five flanking pieces. In 1696, a committee of the Council recommended that a platform be built before the castle and that the northeastern bastion be repaired. This was suggested by the threatening attitude of the French. In 1701 this affair was torn down and there was begun an elaborate and thoroughly scientific fortification of the Vauban type under the personal direction of Colonel William Wolfgang Römer, the chief engineer of the colonies under King William III. The fort was finished in 1703 and dubbed Fort William with a great flourish of trumpets and firing of guns.

The new fort consisted of a square work of regular design having at each corner a bastion. It was built of brick, its walls surmounted by a terreplein and parapet on the eastern and northern sides; while on the southern and western sides were the barracks and offices. There were two exits, to the north and south of this work, each defended by a redan, a shallow, dry ditch around the whole, and this in turn enclosed by a palisade. From the northeast and northwest bastions a continuation of the parapets to the water formed a large ravelin with a water battery of earth extending over the whole front. At the two extremities of this outer work were built, of brick, two demi-lunes which, however, Colonel Römer was never able to complete. Guns were mounted in barbette, but had built over them bombproof shelters, even in the water battery. Leading out from the southern redan was a way, enclosed by palisades, which formed the connection between the fort and a block house, about twenty-five feet square, placed on the southern edge of the island near the wharf. This house, two stories in height, was strongly built

and defended; guns being mounted not only in the upper story; but also at embrasures pierced in the surrounding palisade. In 1736, an additional water battery was constructed on the north-east shore of the island and was connected with the main works by a platform and palisade. This was called Shirley's battery, its erection having been superintended by that officer. The British took possession of Castle Island when they occupied Boston, withdrawing when the evacuation took place. The subsequent history of this island belongs to another period.

Governor's Island.—In 1697, steps were taken for the erection of small batteries on the southeast and southwest shores of Governor's Island. The guns for these were drawn from the north and south batteries and from the Castle. This design was also due to a fear of a French attack. During the entire period of the French and Indian wars the attention of the town was being constantly called to the defenses. With every rumor of a French advance against Boston there was a rush for the fortifications, and appropriations hurriedly passed for their repair. There seems to have been no systematic attempt at scientific inspection and care of these works, After investigation by Selectmen—probably merchants—or by a committee of the Council—probably lawyers—a condition of ruin was usually reported, whereupon repairs would be begun. A few years would bring about the old neglect and the former necessity for repairs. Now and then additions were made to the armament by the home government. Gradually the small, inoffensive guns on old Fort William and Mary were replaced by 12, 18 and 24-pounders, when Römer had made an effective Fort William. In time, even heavier pieces were mounted here, the smaller fry being relegated to the little batteries on Governor's Island and elsewhere. In 1744, we read that twenty 44-pounders and two mortars arrived from England and were placed in battery at Castle Island. This had now grown into a really formidable work for that period; but a bad military policy introduced negligence and unwise parsimony which many times rendered the fortifications weak and inefficient.

THE PERIOD OF THE REVOLUTION AND 1812 TO 1833.

Under the rights of the charter of the Colony of Massachusetts Bay the fortifications of the town were occupied at all times by the militia of the Colony, who were under the direct control of the civil authorities. When the hostile intention of the Colonists in Boston towards the home government could no longer

be doubted or suppressed, troops were sent to the town in 1768 and orders issued to Governor Hutchinson, in September, 1770, to turn over all the defenses to General Gage, or to anyone authorized by him to receive them. Accordingly two regiments with an artillery detachment of British regulars appeared for the first time as unwelcome guests and took up their quarters on the Common and at Fort William, which they continued to occupy until the withdrawal in 1776. As time passed and the rebellious feeling grew more apparent and defiance of authority more audacious, General Gage began to place his command in a state of defense.

The well known memorable events of the spring of 1775 at Lexington and Concord brought matters to a crisis; and after the army of Great Britian had fallen back growling into its lair within the limits of Boston, it soon became aware that the country around it was growing rapidly into a huge military camp and that it was being hemmed in on all sides. The siege of Boston began immediately after the retreat of the British from Concord, by the assembling, organizing and encamping of large bodies of volunteers on the heights about the town. This movement was too confused and undirected at first to result in more than mere assembly; but gradually the plan of the siege developed, lines were drawn, regiments organized and stationed, and fortifications begun. In May and June, 1775, the first lines of entrenchments were thrown up at Cambridge and on the Cambridge road to Charlestown at the foot of Prospect Hill. Then came the seizure of the Charlestown peninsula by the Americans, the fight at Breed's Hill and the immediate occupation of Charlestown Neck by the British after their victory.

The first military result of the battle at Charlestown was a feverish eagerness to throw up field works over the whole front of the American lines. It soon becane apparent that all points of these lines must be made strong and guarded, as it was impossible to say where the enemy would appear in force. From this time until the coming of General Washington to assume command, the work of fortifying went rapidly on, under the spur of constant alarms of sorties by the British. Like magic the forts, redoubts and lines of intrenchments sprang into being. Heavy guns brought from every available corner of the colony, and even beyond it, were mounted on the commanding places and soon opened fire on the beleaguered British. On July 3,

Washington assumed command and immediately ordered additional works which were made in spite of strong opposition by the enemy. During the autumn and winter the fortifications had approached within half a gun shot of the British works in every direction, except at Dorchester; and with the increase of his ammunition supply, Washington designed and carried out the decisive move which he had been compelled many times to lay aside from lack of the proper opportunity. On the night of March 4, 1776, Dorchester Neck was passed quietly and the late morning of the memorable 5th disclosed to the British in Boston the heights of Dorchester commanding the town crowned by earthworks and filled with armed men and cannon. This was the death blow to the British occupation of Boston; and on the 17th they withdrew to their ships as the Americans entered the town with flags flying. The fortifications erected by the Americans, in actual length of parapet, were about twenty miles long. Those for guns were furnished with wooden platforms and usually had bomb proofs for the guns and covered ways leading to the batteries from shelters in rear. These works took the form of enclosed forts at the most exposed points, being finished with ditches, entanglements and abattis, and in some cases constructed with skill and care. In certain places, as at Lechmere's Point, the battery was erected at the water's edge, being connected with works behind by artificial causeways. It was found necessary to do this along the banks of the Charles in order to get within mortar range of the town. Time and improvements have long since swept away the evidences of our forefathers' patriotism and military energy and skill; and there remains to-day no material evidence except a monument and here and there a tablet showing the site and works that cost them such labor and hardship, and the British the loss of half a continent.

In fortifying Boston, Gage, and after him Howe, erected works to prevent the ingress of the enemy at Charlestown Neck, Roxbury Neck, and an advance across the back bay. The works at the two necks were very strong; being high bastioned ramparts, with entanglements, ditches, moats and palisades and other well known obstructions to the movements of an attacking enemy. At Boston Neck were mounted fifty-two 6. 9. 12, and 24-pounders, besides mortars and howitzers. At Bunker Hill and Charlestown Neck some twenty guns and mortars were placed, with several lines of intrenchments for infantry in front. In the town small redoubts and intrenchments were thrown up at every available point, but they would have been of little value against an assault.

Of these a writer of the period says, "they appeared to be ill constructed and designed for little but to frighten us." Most of the British works were destroyed at once after the evacuation, only those being retained that were considered necessary to meet an attack from the sea. These were the ancient Fort Hill redoubt, the north and south batteries and Fort William.

Immediately on the withdrawal of the British from Boston harbor General Artemas Ward, left in command there, ordered the erection of various works, designed to meet an attack should the British seek to return. In addition to those in Boston, a work was made on Noddle's Island at a point known as Camp Hill, now Belmont Square; others at Charlestown Point, Castle Point, and a number of heavy cannon were mounted in each. These, however, barely outlasted the Revolution.

From the close of the Revolution to the war of 1812, changes were taking place in the city and harbor of Boston at the various fortified points. Around the city, the plow and pick entered ruthlessly on the destruction of the late besieging works; while in the city, neglect soon brought decay, and finally the auction block disposed of Boston's interior and water defenses. In the harbor, quite a different transformation was in operation. The military hand of the General Government was first seen in the harbor in 1798, when Castle Island was ceded to it.

Although the Commonwealth of Massachusetts was violently opposed to the war of 1812, and unhesitatingly raised its voice in condemnation, it could not be blind to the possibility of an attack on the navy yard and shipping, nor to the fate of the city of Washington. Efforts were made to arouse the interests of the citizens in the common defense, which resulted in the building, by volunteer labor, of a number of small batteries and works, the most important of which was that on Noddle's Island. In September, 1814, work was begun here by the volunteer labor of trade societies, one of the petitions signed by the mechanics of the town being headed by the name of Paul Revere, an engraver as well as a patriot. Under this impulse the work was begun, though it required more than one patriotic prodding to complete it; but finally it was in a state to be occupied and named Fort Strong in honor of the Governor of the State. No service was ever demanded of this work, which remained for many years untenanted, the last vestige becoming obliterated in 1833.

When the soldiers of Washington reappeared within the defenses of Fort William on Castle Island, they found only smoking débris and dismantled parapets. The British at their departure

had played havoc with the fort and its armament, breaking off the trunnions and cascabels of the cannon given to the Castle in 1740, destroying all military stores and battery apparatus, and finally blowing up the citadel and two magazines, leaving them a mass of ruins. In the efforts immediately taken to give the hostile fleet a warm reception should General Howe change his mind about evacuating, the old walls were put together as well as the circumstances would allow and the guns prepared for action; at the same time the name was changed to Fort Adams.

When the first fear of the British return had passed, the works were repaired as rapidly as possible. The rubbish was moved into defensible shape, a destroyed bastion of the fort was replaced, the mutilated 42-pounders restored to reasonable strength by affixing new trunnions—a device supplied by the inventive genius of Paul Revere—a wooden citadel was built and a new magazine of stone replaced the ruins of the old. In 1778 the British man-of-war *Somerset* was wrecked on Cape Cod and her battery furnished a handsome array of twenty-one 32 pounders to the restored fort. Considerable work was done on the fortifications in 1780, under an act requiring a day's "fatigue" by each male inhabitant of Boston. In 1785, the island became the place of confinement of convicts; but a few weeks before the transfer of the island to the general government, the convicts were withdrawn.

The year 1797 saw that unpleasant episode which led to our hostile attitude towards the French Republic. One of the measures taken by the general government for placing us in a defensive condition was the assumption of control of our sea-coast fortifications, among them Fort Adams. The actual transfer took place, October 2, 1798, by which the United States obtained the island, a fort and twenty buildings more or less in need of repairs. The ordnance stores after apprisal were paid for by the quartermaster general and amounted to about $21,000.

During a visit to the island by President Adams in 1799, he named the fort then in contemplation, Fort Independence, the first stone of which was laid by its projector, Colonel Toussin of the Engineers on May 7, 1801. The fort was located on about the same ground formerly occupied by Fort Adams better known as Fort William, although that work was entirely obliterated before the new foundations were laid.

The fort built by Colonel W. Tell Toussin, late governor of the French colony of Cayenne, was an enclosed star fort, almost regular in design having five bastions, with an average length of

about 375 feet between adjacent salients, or points of the star. It was made of earth, faced inside and out with brick and had sodded parapets for mounting barbette guns. In front of the northern face was a redan with embrasures cut for ten guns. Within the walls were erected brick buildings for barracks and officers quarters, and a magazine of stone. The greatest height of parapet above low water was fifty feet. One of the inmates of the fort at that time writes of it, "the works of Fort Independence were pushed with great vigor from their foundations to their parapets. An immense labor was performed within a short time (about a year and a half) by the accurate calculation and indefatigable attention of the engineer. There were men, mechanics and laborers, daily employed, besides the assistance of the garrison. The buildings, both commodious and handsome, were erected and the walls, large masses of brick, earth and sodding were finished before the end of the year. Colonel Toussin, in January 1803, had nearly completed an elegant and commanding fortress to one of the most beautiful harbors in the world." Allowance must be made for the enthusiasm of a commanding officer, for such was the writer of the above. The drawing shows that this Fort Independence was a work of the simplest order and in extreme contrast with the elaborate engineering puzzles which were being erected in Europe at that time. The dimensions of the work were in natural proportion to the modest size of the congressional appropriation.

Governor's Island—Fort Warren.—In the same act ceding Castle Island to the United States, permission was granted to the agents of the general government to purchase Governor's Island for the building of forts, magazines and other works necessary to a military occupation. Under this and a subsequent act, a purchase of six acres for the sum of $15,000 was made May 18, 1808, and again of the remaining sixty-four acres on the island on October 14, 1845, for the consideration of $10,000. As soon as the general government acquired possession in 1808, it at once began to fortify on plans sent out by the War Department. At this time war was confidently expected with England and large appropriations for the defenses of the Atlantic coast were made by Congress. The engineering bureau, then under the control of Colonel Burbeck, sent out scores of plans, medieval in design and conception, to the officers in command at the various harbors with orders to enter at once on the work. No regard whatever was paid to proper location or the adjustment of the military works to the sites obtainable; while the forts themselves, usually

star shaped, were too small for flank defense and too complicated for mere batteries. General Swift, then at Boston, strongly recommended George's Island and Long Island Head. The wisdom of his selections was shown in 1833 by the erection of the present Fort Warren and again to-day by the works on Long Island Head. In consequence of this fever for fortifying, a star fort named Fort Warren was begun on the summit of Governor's Island, with a lower battery on the southwest shore, and later in the year, a water battery at the eastern point of the island.

The work on the summit was an eight pointed star fort, faced with granite, surmounted by an earth parapet for barbette guns. The sides of the square on which the pointed redans were built were about 114 feet long, indicating a very insignificant work. There was no ditch but a palisade surrounded the walls. Entirely enclosing this little work was a parapet ten feet high for infantry fire. The general outline of this was rectangular, being 405 feet long and 270 feet wide. South of this, at the water's edge, was built a half moon, granite faced battery, the parapet pierced by eleven embrasures. To oppose attack by landing parties, there were constructed along the northern and eastern shores overlooking the channel towards Apple Island, several works of the simplest order for infantry defenses: one, an open redoubt with a short curtain connecting two small bastions; the other a zigzag infantry intrenchment about 750 feet long. On the extreme southeastern point was begun, but never finished, a queer, irregular, low redoubt, with a semi-circular curtain and a parapet intended for barbette guns; the whole scarped and faced with cut granite.

The completion of these works marks the close of the second period of fort building in this country. The old method of palisades, low site to obtain the advantage of ricochet fire, and mid walls, had almost disappeared in the construction of the works brought about by the impending war of 1812. Old fashioned ideas still held their own at the military headquarters of the country, in the minds of the unscientific though earnest veterans of the revolution. In Boston harbor, nature helped the military defense more than the faulty plans of worn out generals and enabled the young but progressive and active corps of engineers to remedy in part the unscientific crudities of headquarters. The forts thus briefly described, belonging to a middle stage between the ancient and modern, lasted many years. Parsimony had stepped in and nothing beyond repairs was done to the Boston fortifications until the awakening of 1833.

One of those sudden bursts of congressional generosity swept over us about 1834, and that too unimpelled by any threat of war or complicated foreign relations. Colonel Sylvanus Thayer, one of the foremost military engineers of the day, took charge of the work in this harbor and under him and other eminent men of that corps, were produced the fortifications which remained the only defense of this harbor up to about five years ago, when the first steps were taken toward the construction of modern works. The present Fort Independence is the eighth and probably the last military work erected on old Castle Island. In laying it out, Colonel Thayer followed the lines of the Toussin fort of 1803, the outer faces of the walls being carried just outside of the former work, thus incorporating some of the old foundation. The fort is standing to-day and is too familiar to need discription. The fort has not been occupied by a regular garrison for many years; and at the present time the ground outside the fortifications have been converted into a park by the city of Boston with which the island is connected by a causeway.

Fort Winthrop.—It may be inferred from what has been said of the origin of old Fort Warren that the earliest opportunity would be taken to obliterate this very unserviceable work and place in its stead a fortification worthy of the grand site which it occupied. About 1842, Colonel Thayer began the work now known as Fort Winthrop. He selected nearly the same spot where had stood the old star fort and erected there a granite keep, three stories high, with a basement for supplies, and a roof strong enough in design to support a battery of sixteen guns. This keep, 85 feet square, was surrounded by a rampart high enough to hide all but the top of the keep, being 210 feet square and 20 feet thick at the bottom. The half moon battery on the south shore remained the same, but above it, on the sides of the hill, were erected two detached earthworks mounting 23 guns. On the north and east shore, to guard the passage toward Apple Island, were two detached works, mounting in all twenty-seven guns. Very material changes were made in 1871. The rampart surrounding the keep became a bastioned earthwork, mounting eleven of the heaviest guns obtainable. The detached batteries were united, making continuous lines of works, supplied with traverses to cover magazines. The keep and batteries were connected by bomb-proof galleries; and finally a number of mortar beds and parapets were built but never occupied by the guns. From the building of Fort Winthrop to the present day not a soldier of the line has ever done garrison duty within its ramparts. This fact makes

its story the most unique in the history of forts. So slow was the work upon it and so rapid the development of large ordnance since its first stone had been laid, that it was in a constant state of adjustment to new armaments, and therefore never ready for occupancy. Emplacements were made for guns which, before they were fairly in position, found themselves obsolete, and others came to take their places. The struggle to be modern finally ceased; and the guns of Winthrop were dropped where they were, and there they lie to-day, harmless and inert, a fair example of the results of our puny efforts to keep up with the progress of military science during the twenty-five years that followed the civil war.

Fort Warren, George's Island.—General Swift's wise suggestion to the War Department relative to the location of a fort on George's Island obtained a hearing after the lapse of seventeen years, at which date the government entered into the negotiations finally ending in its purchase in 1825. In September 1832, the first surveys were made on George's Island with a view to the building of a fort, and in the spring of the following the work was begun under the direction of General Thayer. Under his direct superintendence there was here erected one of the strongest stone forts in the country, if not in the world. The best of granite was used and the latest engineering devices employed for flank defense and resistance to infantry attack. The glories and beauty of the masonry fort are here exemplified. The ponderous rampart, faced inside and out with beautifully chiselled granite, rises high above the tide, showing on some of its faces rows of dark mouthed embrasures; the lofty grass grown parapet, bearing long lines of barbette guns; the low water batteries adding still another tier of cannon—the whole forming a massive structure of faultless military engineering, which with its impenetrable walls and its 238 guns, would easily have overmatched the ships and guns of the days before the great war.

Although the work on Fort Warren was begun in 1833, its erection proceeded with extreme laggardness, due partly to the smallness of the annual appropriations. The beginning of the rebellion found it still ungarrisoned, although nearly in readiness for occupation. The first troops to take possession were certain Massachusetts volunteer infantry; but these were gradually replaced by the Salem and Boston Cadets; and finally by several companies of volunteer heavy artillery. A regular garrison did not appear until October, 1865, when four batteries of the Third Artillery were ordered to relieve the volunteers. The garrison

at this period was occupied in the safe-keeping of prisoners of war, a large number of whom, both soldiers and civilians were in confinement here. Here were placed Mason and Slidell until turned over to the British. Alexander H. Stevens and John H. Reagan were also prisoners here, being released by order of the President on October 13, 1865.

From the close of the war of the rebellion to 1875, Boston harbor received but little of the limited appropriations for the construction of new works. In the next fifteen years not a dollar was appropriated for this purpose here or in any harbor on the whole coast. By the acts passed in 1890 and 1891 Boston received for the construction of forts $277,233.33; and for buying of ground, $273,637,22. A broad scheme for defense has been entered on, sites have been purchased at numerous points and modern works have been called into being by fair annual appropriations by Congress. The work, however, has only just begun, but the awakening is encouraging and the future seems hopeful.

HARRY L. HAWTHORNE,
First Lieutenant, First Artillery.

PROFESSIONAL NOTES.

ORGANIZATION.

The Turkish Army.

The military forces of Turkey may be said to consist exclusively of Turks proper, as nomad Kurds and nomad Arabs, although liable to serve, are not recruited, and Christians are allowed to pay an exemption tax. All Mussulmans come under the recruiting law at twenty years of age, and (says the *Pall Mall Gazette*) remain in the force until forty. Of the twenty years, six are passed in the Nizam or regular army, eight in the Redif or Landwehr, and six in the Mustahfuz or Landsturm. About 140,000 Moslems become liable to serve yearly, and of these some 50,000 pass into the Nizam and serve their four years with the colors, and then remain on the reserve until the time comes for them to pass to the Redif.

The total strength of the combatant forces of the Turkish Empire is upwards of 700,000 men. In 1887, Turkey obtained a supply of large-bore magazine rifles, but these are now being converted into small caliber, so as to take the same ammunition as the small-bore (.3012-in.) Mauser rifles of the Belgian pattern, which were introduced in 1890. This latter, which is the arm of the regular infantry, carries five rounds in the magazine, and fires a hard lead bullet, coated with cupro-nickel, with a muzzle velocity of 2,139 feet per second. The rifle is sighted up to 2,000 meters (2,187 yards).

The artillery, which has been re-organized recently, is armed with nearly 1,400 guns, about 900 of which are new pattern Krupps, the rest being older Krupps and Whitworth guns. That the men are available and that they would be well armed is certain. It is, however, doubtful if sufficient horses fit for active service could be supplied to meet the requirements of two hundred cavalry squadrons, and nearly as great a number for horse and field batteries. Another difficulty is the lack of communications, and it is probable that, owing to the want of sufficient rolling stock on the railways, especially in the Asiatic provinces, a large force could not be concentrated in any distant part of the Empire for many months.

The army is organized on the territorial system, and the Ottoman Empire is divided into six great military districts. Western and south-western Arabia comprises a seventh district, but its recruits are drawn from districts in Turkey. The garrisons of Crete and Tripoli are also recruited from Turkey. Each of the six districts contains an army corps of two infantry divisions, a cavalry division and other troops belonging to the Nizam. The Redif is also organized in twenty-two divisions spread over the six districts.

It would appear, therefore, that, notwithstanding certain drawbacks in the way of a rapid mobilization of all the forces of the empire, a powerful and well-organized army is at the back of the Sultan, and when the stand the Turks made for hours at the battle of Zewin during the campaign in Armenia in 1877 is remembered, it cannot be doubted that in a struggle for the integrity and independence of their country they would exhibit a military spirit and endurance that would not be easily overcome.

—*United Service Gazette*, October 3, 1896.

The War Power of Spain in case of Mobilization.

The Spanish periodical *El Correo Militar* publishes, in consequence of the position taken by the United States on the Cuban question, a comparatively long article on the forces which Spain, in case of war, could mobilize in a short time. We reproduce here the most important part of this article, for although reliable sources are available for facts relating to the organization and strength of the Spanish army in time of *peace*, as, for example, *von Löbell's Jahresberichte*, little or nothing has thus far been made public in regard to the war organization of the army and its strength.

The Spanish *Peninsular Army*, exclusive of the garrisons on the Balearic Isles, the Canarian Islands and in the possessions in North Africa, consists in case of mobilization, aside from the 56 battalions of the line and the 10 Jäger battalions at present in Cuba, of:

Infantry.

56 second battalions of 1000 men each	56,000.
56 third battalions of 1000 men each	56,000.
10 Jäger battalions of 1200 men each	12,000.

Cavalry.

28 regiments of 596 horses and 700 men each	19,600.

Artillery.

14 field artillery regiments of 8 batteries of 6 guns each, and the same number of ammunition columns of infantry and artillery	25,606.
3 mountain regiments with ammunition columns	7,254.
7 battalions garrison artillery of 6 or 4 companies each	8,175.

Engineers.

4 sappeur-miners regiments of 2000 men each	8,000.
1 pontonnier regiment	3,442.
1 railroad battalion	1,040.
1 telegraph battalion	1,272.
Total	198,389.

To these must be added administrative, medical, etc. troops, amounting to 4845 men. The cavalry has 16708 horses, the artillery 816 field pieces.

The Reserves available are:

Infantry.

112 reserve battalions (56 regiments) of 1000 men each	112,000.

Cavalry.

14 reserve regiments, each of 4 squadrons, of 600 horses and 702 men each	9,828.

Artillery.

7 field regiments, 1 in each army corps district, and 138 guns.	14,140.

Engineers.

New subdivisions	6,000.
Total	141,968.

Exclusive of the forces in Cuba, amounting to 130,000 men in round numbers, the Spanish army after mobilization will count 340,000 men, 25,108 horses (cavalry) and 952 guns.

For mobilization the following men are available:

(1) *Active Reserve.*

Class of 1891	10,324	
Class of 1890	25,465	
Class of 1889	28,461	
	64,250	
Deducting 10% losses	6,500	
	57,750	57,750
Class of 1895	9,836	
Class of 1894	19,900	
Class of 1893	60,054	
Class of 1892	56,585	
Class of 1891	50,784	
Class of 1890	41,573	
Class of 1889	42,942	
	281,674	
Deducting 15 to 20% for losses . . .	56,000	
	225,424	225,424

(2) *Second Reserve.*

The following instructed men are on hand:

1st army corps district	26,851	
2nd " " "	34,623	
3rd " " "	24,093	
4th " " "	16,332	
5th " " "	12,393	
6th " " "	16,710	
7th " " "	26,173	
Baleares district	2,354	
	160,029	
Deducting 20% for losses	32,000	
	128,029	128,029
Total		413,453

Of the second reserve about 70 per cent. belong to the infantry, 12 per cent. to the cavalry, 11 per cent. to the artillery and the remainder of 7 per cent. to the administrative troops. Besides these there is available a second group of the second reserve of about 400,000 men, which have not, however, received any military instruction.

In addition to the troops above mentioned there are the following garrisons:

(*a*) Balearic Islands—two regional infantry regiments, two reserve regiments, a garrison artillery battalion, a squadron and a company of engineer troops.

(*b*) Canary Isles—two Jäger battalions, six reserve battalions, Provincial guard infantry and cavalry and a garrison artillery battalion.

(*c*) Africa—four African infantry regiments, a disciplinary battalion of Melilla, a mixed artillery battalion, a squadron of mounted Jägers of Melilla, a squadron of Jägers of Ceuta, a company of Moorish rifles, one of Melilla, one of Ceuta, volunteer militia of Ceuta.

Tha troops classed under *a*, *b* and *c* have a strength (in the event of mobilization) of about 25,000 men.

Of *Guardia Civil* (Gendaımes) there are available over 15000 men with 2200 horses, of *Carabineros* (customs guards) over 14000 men, or a total of about 30,000 men.

The entire infantry of the line will probably be armed in a reasonable time in consequence of the contract made with a foreign manufactory and the increased activity of the national armory, with the new Spanish Mauser gun M/93, while for the subdivisions of reserve to be formed there are in store a sufficient number of Remington guns of the system recently in use. The guns necessary for the field artillery as well as other material, are held in readiness in the artillery depots.

—*Militär-Wochenblatt*, April 29, 1896.

TACTICS, STRATEGY AND MILITARY HISTORY.

New Method Employed in the Inspection of Artillery Fire Practice in Russia.

(Translated from *Militär Wochenblatt*, October 3, 1896).

On the occasion of the Emperor's visit at the camp of Krassnoe Selo on the 14th of August a new method for the inspection of the firing practice of the infantry and artillery was for the first time put in practice, with the object of testing not only the pure artillery training, but also the tactical training in combination with infantry under different conditions in battle. In regard to a preliminary exercise of smaller subdivisions the *Russian Invalid* remarks as follows: For this purpose a subdivision was formed, composed of two companies on the war footing and two batteries of eight pieces each. The problem for the artillery was to select the position, and then fire, first against fixed targets, under cover, representing a hostile battery, and then against targets representing an advancing line of hostile infantry. The infantry attached to it had to fire, from a position which it selected and occupied, on movable targets. In order to show what little danger there is in passing, at comparatively short distances from the position, along the front of artillery firing at 900 or more sashes (1 sash is 7 feet), several horsemen were directed to move at a walk from the right flank across the line of fire at a distance of 400 sashes. As a precautionary measure, however, only percussion shell were fired (no shrapnel).

The firing on the battery target lasted 18 minutes, after which the moving targets representing the infantry line, was taken under fire, due allowance being made for their rate of advance. The advance by rushes began at 800 paces, and the line approached the firing artillery in an oblique direction to within 300 paces. The infantry took part in the firing sometimes by volleys, sometimes by firing by file. The artillery fired on the approaching line one volley ot shell and three of shrapnel. The effect was "very good."

In future the exercises and inspection, in order to give greater prominence to the tactical side and to make them conform more nearly to the requirements of actual war, will be conducted as follows: The inspection will last two days, and will be combined with an attack against actual troops of all

arms, which will be represented by targets only immediately before opening fire. The firing constitutes, therefore, only the final act in a maneuver.

On the first day the subdivision on the defensive will be required to hunt up the enemy and hold him first in the advanced position, then in the intrenched principal position. The attacker, on his part, will be expected to carry out his marches with all necessary measures for security and information, to open the battle with the enemy's advance guard and to pass to the order in battle, in which the firing from the first (preliminary) artillery position will be with blank cartridges. The entire detachment will continue to advance until the commander has decided upon his plan of attack, based on the reports of the patrols and on personal observation. The chief of artillery assists him in all that relates to the artillery.

As soon as the infantry has taken up its position, and the batteries have set their sights for the proper range, the maneuver is brought to an end for the time being by the President of the Examining Committee. The positions taken up by the batteries and the infantry are then marked by flags, those of the chain of skirmishers in front of the batteries by figure targets. As soon as the attacking party has moved away, the enemy sets up the targets to mark his position and is then marched off.

On the day of the actual firing the attacker again takes his positions as marked by the flags, one after the other, in proper succession. The defender is also taken out and so placed to one side of the position that he can see his targets and can judge of the effect of the firing.

Then the artillery and infantry of the attacker open fire on the targets at the elevations decided on the day before and continue until the Examining Commission of the artillery orders the next position to be taken up, where the firing is completed.

"In this way—writes the *Invalid*,—it is possible, on the first day to arrive at an opinion on the tactical instruction and training of the artillery, and on the second to test its proficiency in firing." The inspection held in the presence of the Emperor on the 14th of August was conducted according to this program. Three battalions (war strength), 2 sotnias, 32 field guns, 6 horse artillery guns, 6 mortars and 2 of the mitrailleuses (pulemeti) recently introduced were designated to do the firing. The enemy was represented by two battalions, a half-squadron and eight guns. It is hoped that a nearer approach to the conditions of actual war will be attained by the general introduction of this mode of carrying on an inspection and conducting the introductory exercises than has thus far been the case, it is only a question whether the time available in the short camps will suffice for the actual execution of this method, due in great measure to the efforts of Grand Duke Vladimir.

—*Russian Invalid*, No. 169.

ARTILLERY MATERIAL.

a. Guns and Carriages.

The New French Quick-Fire Field Gun.

One of the points which occupied the attention of Li Hung Chang, during his recent tour through Europe, was the progress made by different nations in the development of quick-firing field guns. It is said that he was, at St. Chamond, in France, initiated into the mysteries of the new French field artillery of this character, which is interesting scientific gunners so much at present.

The application of the quick-firing principle to field guns of ordinary caliber, although an idea of somewhat recent growth, has been the dream of enthusiastic artillery officers, and of the large war material producing firms, ever since its success was so entirely assured in regard to naval guns. But the difficulties appeared to be insurmountable. The jump and recoil of a field gun seemed to be inseparable features attaching to its employment. Then there was the prejudice against carrying ammunition fitted with primers in limber boxes; and however one might reconcile oneself to the dangerous character of this last condition, the fact that a very slight movement of the gun in recoil destroyed the elevation and training was fatal to the application of the principle, unless the movement could be absorbed. Messrs. Grüson of Magdeburg, experimented for years with quick-firers of various types, having calibers up to 8 centimeters, and an elaborate system for correcting the deviation in direction caused by recoil, the weight of the carriage being greatly increased by that of the mechanism required; but it was found that the carriage, even when perfectly skidded, ran back nearly a meter, and that it was only with much smaller calibers that the recoil could be absorbed within manageable limits.

In our own country we do not think that the system has hitherto had a fair trial. So great is the feeling of field and horse artillery gunners against any innovation from perfect simplicity in the form and design of guns and carriages for their arm of the service, that the very fact of a gun being slung in a cradle, and without trunnions, and of its carriage being provided with recoil cylinders and running-out springs or training segments, would be sufficient to condemn it in the opinion of many commanding officers of field or horse batteries. Nevertheless, it goes without saying that the army of the future which is provided with an artillery armament of satisfactory quick-firing field guns, and an ample supply of ammunition, will possess an element of dire and terrible potency, against which ordinary field guns, firing their conventional one or one and a-half rounds per minute, would be absolutely nowhere.

Under these circumstances it is satisfactory to learn that efforts are being made by private manufacturers in this country to supply the much needed quick-firing field gun. We have, by the courtesy of the Maxim-Nordenfelt Company, been enabled to produce in our columns this week engravings of their quick-firing field gun of 7.5 centimeters, which was fired, with remarkable success, upon the company's shooting ranges at Erith, in the presence of Li Hung Chang. We have also been furnished with the following particulars in regard to the gun.

The principal data which have served as a basis in the design of this novel weapon are briefly :—

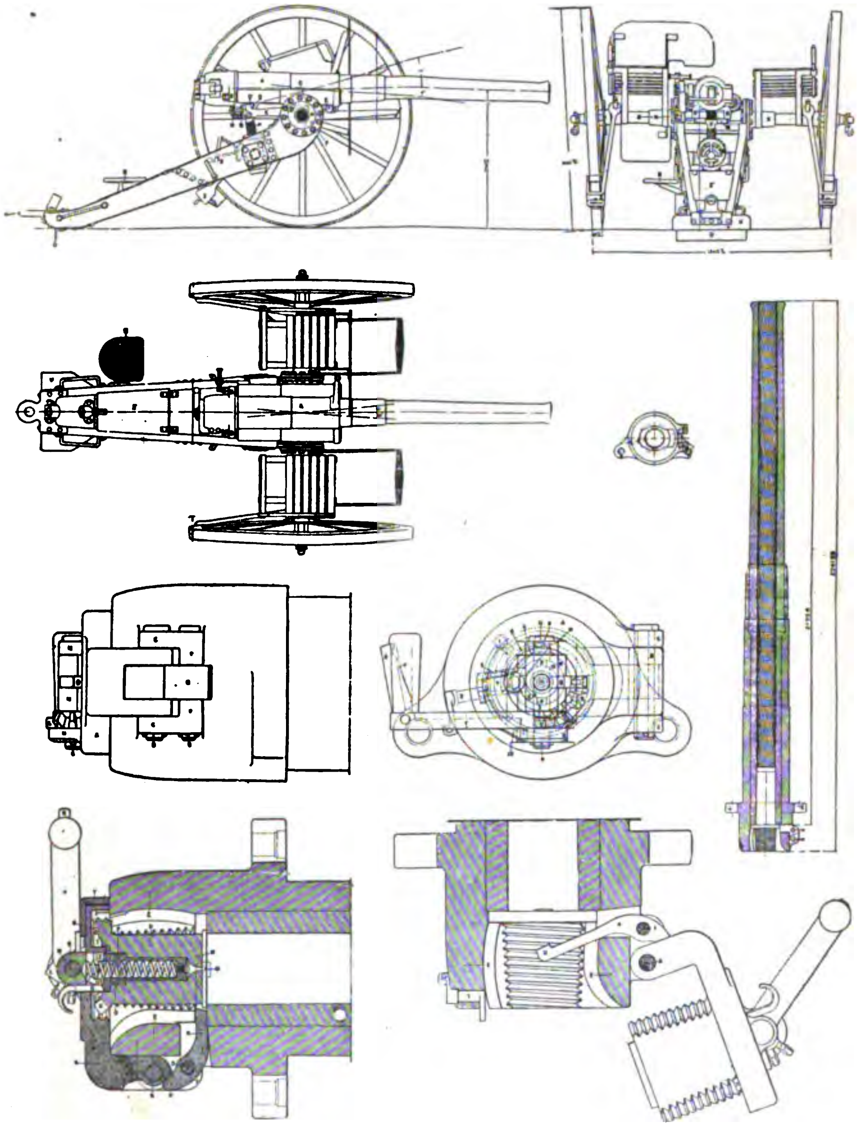
The employment of fixed ammunition with primed metallic cylinders. Closing of the breech with an interrupted screw, of great simplicity, of rapid and easy manipulation, composed of massive parts, and absolutely assuring extraction of the empty cartridge cylinders. Facilities for dismounting, without any tool, of the firing and breech-closing mechanism, admitting of the immediate change of a "striker," or of its spring. Re-cocking the gun without opening the breech. The employment of hydraulic breaks, absorbing part of the recoil, and reduction of the "jump" of the carriage. Separate gear for training and elevation to be worked by the "laying number" who sits on the side of the trail; he also to fire the gun. Automatic brakes of great simplicity on the wheels. A light steel shield to protect the "laying

number" against rifle bullets or shrapnel. Total weight of "heavy equipment" drawn not to exceed 3968 pounds. Total weight of "light equipment" drawn—for horse artillery—not to exceed 3307 pounds. Employment of a single projectile, with a few rounds of case shot.

The gun is of the ordinary tempered steel type. Being intended to slide in a cradle, which forms part of the carriage, it does not carry trunnions. The two projections A (see plate), receive the piston rods of the hydraulic brakes, while upon the right side of the breech are found the lugs B of the hinge for the breech-closing gear, and the lugs C forming the supports of the extractor. The grooves of the rifling are thirty in number, uniform, and their angle of inclination is 6 degrees. Their width of 5.8 mm. at the commencement diminishes gradually to 4.9 mm. at the muzzle, causing a continual compression of the driving ring during the passage of the projectile through the bore of the gun, which diminishes the chance of gas escape and consequently of erosion. The depth of the grooves is 0.58 mm.

The breech-closing gear is somewhat different to any hitherto employed. The breech-screw D is actually conical, but its largest diameter is at its interior extremity. Nevertheless, it hinges out upon the carrier A without any longitudinal movement being required, the seating E being sloped away to a certain extent to admit of this. This arrangement is said to obviate all possibility of the breech gear being forced out by excessive pressures. The extremity of the manipulating lever F has a segmental pinion I engaging with a cogged segment K in the breech block. The first portion of the movement then makes the block revolve and unscrew 90 degrees, the cogs of the pinion being placed excentrically to its axis, so that they recede as the block goes out and preserve their engagement. A claw on the pinion now sets against the breech block and brings it out, instead of making it revolve further. The 90 degree revolution brings the threaded portions of the screw against the smooth portions of the seating. The striker M is actuated by a spring pressing between the sleeve N and its solid point. Turning the breech block presses the two helicoidal surfaces O upon projections P behind the striker, and cocks the gun, the striker itself being prevented from rotating by the directing arm Q, which can only work longitudinally. This directing arm is prolonged beyond the carrier and ends in a hook, by which the gun can be re-cocked in case of a miss-fire without opening tne breech. The extractor R oscillates around an axis S fixed in the two lugs T; it has two extracting claws V. By the movement of the curved heel V the process of extraction, slow at first, finally ejects the empty cartridge cylinder with a jerk. The ordinary trigger mechanism is seen at X Y Z and the firing lever 2. A safety trigger, composed of a heel at the end of the prolongation of Y, slides in the groove 5, and prevents the act of firing until the moment when the breech is closed. The breech block is prevented from oscillating unduly around its axis by a spring button 7. A bent lever, actuated by a spring, something like the brake on a bicycle handle, secures the working lever of the gun in its position against the breech when closed. The breech-closing gear is provided, when required, with an arrangement for preventing the opening of the breech in the event of a hang-fire having taken place. It is only released by the shock of discharge.

The carriage has a jacket or cradle A of cast steel, in which the gun slides, fitted with hydraulic brake cylinders, favorably situated with regard to the axis of the gun and the line of recoil. The recoil in the cylinders is 12 inches. The gun jacket and hydraulic brake are upon a semi-circular platform E,



being secured by the clamps D and D^1. The pivot E is the center of movement of the whole system for a training of 9 degrees. The lower part of the pivot F and the cushion G work by a screw upon the fixed cylindrical axis H, secured to both brackets of the carriage. It will be seen, by a reference to the drawing, that the axis of the gun is low down, and very near the center of the axle-tree, and consequently that the angle of the trail is a very acute one, if the wheels are of the ordinary height. This is a great advantage, as it prevents jump. A cogged segment L, engaging with the endless screw M, manipulated by the training wheel N, gives training through an arc of 9 degrees without altering the position of the trail. The elevating screw and wheel can be seen at P and S. They admit of 15 degrees of elevation and 5 degrees of depression. The sights are fixed upon the side of the jacket, and consequently do not recoil with the gun. This is a manifest advantage. The training and elevating wheels are so placed that the "layer," seated upon the seat R, can without any inconvenience elevate, having the right hand upon the wheel S, whilst with the left he works the training wheel N. The elevation once obtained, his right hand is free to pull the trigger and fire the gun. The extremity of the trail is provided with a short spade U, for the purpose of further checking the recoil, fixed beneath a plate V, sufficiently large to prevent the burying of the trail in the ground. The axletree carries at each side, near the wheels, a ring Y, the position of which is slightly excentric in regard to its axis, each ring receiving the end of a drag iron Z intended to skid the wheels during firing. These drags are in all respects automatic, for the more the wheels have a tendency to turn during recoil, the more firmly are they skidded. On the march the drags are hung at either side of the trail. Z^1 is a trail box for tools, sights, spare parts, etc. The carriage is provided with a steel shield, 6 mm. thick, of special quality, resisting rifle bullets at a distance of 20 meters.

The following are the principal dimensions and particulars which should be noticed:—

	Heavy gun.	Light gun.
Caliber of gun—7.5 centimeters	2.95 inches	2.95 inches
Length of gun	30 calibers	24½ calibers
Weight of gun and breech gear	734 lb.	624 lb.
Height of axis of gun above ground	36.34 in.	33.25 in.
Weight of the carriage with wheels	1828 lb.	1431 lb.
Angle of recoil upon the ground	30 deg.	30 deg.
Weight of loaded projectile—shrapnel	13 lb.	11¾ lb.
Weight of round complete of fixed ammunition	16 lb.	14 lb.

The fixed ammunition is loaded horizontally in limber boxes, thirty-six rounds being carried with the heavy gun equipment, and forty-eight rounds with the horse artillery equipment, upon the gun limber. The initial velocity with the heavy gun is about 500 meter-seconds.

The above is a very much curtailed description of this new quick-firing field gun, which appears to answer the majority of the requirements demanded by modern horse and field artillery. It is wonderfully light, well placed on its carriage as to recoil, and the entire weight behind the team considerably less than that carried by our horse and field batteries. One of the principal questions which occurs to us is the supply of ammunition to the quick-firing

field gun of the future, as the limber boxes are exhausted. With rapid work the gun limbers and ammunition wagons would be emptied in a very short time, and the arm would be helpless if there was no reserve handy. This point has, however, nothing to do with the efficiency or non-efficiency of the gun we have been describing. It worked with the utmost smoothness at Erith, in the presence of Li Hung Chang, and the difficulty of recoil appears to have been grappled with in the most masterly manner, without unduly increasing the weight of the carriage. Of course, the spade would not strike into the ground if there happened to be solid rock beneath the trail, but this would probably be an unusual circumstance.

—*The Engineer*, September 25, 1896.

The new Howitzer for the German Foot Artillery.

The German army undoubtly possesses in its recently constructed 15-cm. howitzer an excellent high angle gun, destined, in spite of its large caliber, to be taken into the field at once at the beginding of a war, where it will, no doubt, give a good account of itself. The mobility necessary for this purpose the new gun, which is to be drawn by four horses, possesses to a marked degree, while the caliber of its projectile is the same as that of the short 15-cm. gun of the siege and fortification artillery. Each army corps is to take at least one of the new howitzer batteries into the field at once, while the other, held in reserve for the present, must be ready to be called into service without delay when required. In the way of siege guns, which are to be taken into the field for the purpose of besieging fortifications, may be mentioned: the 21-cm. mortar, the long 15-cm. mortar and the short 15-cm. gun; the 15-cm. mortar has been rejected as it did not prove efficient. The new howitzer is intended to be used for two different purposes.

The *first* is against large targets under cover, as, for example, troops assembled behind villages, woods, undulations of the ground, and other obstacles obstructing the view, which require the highly curved trajectory of guns of high-angle fire to reach them. When we consider the weight of its projectiles (40 kg.) and the radius of dispersion of its fragments (about 400 meters), we can form some conception of the violent action of this new gun, the pointing of which on *covered* objects is by no means so uncertain or difficult as might at first sight appear. The ingenuity of the artilleryman will be able to supply the necessary means of laying it with sufficient accuracy and giving it the correct elevation, or, leaving out of consideration the methods in use to attain this object, the maps available will perhaps furnish the data necessary for the proper use of the gun. The trajectories of the field guns at present in service have, as is well known, certain limits of range up to which targets under cover can be reached with the necessary energy, and even in case of shell charged with high explosives, and which are capable of acting against all cover in the field, do not, in consequence of the peculiar character of their fragments (splitting up, as they do, into fine particles like glass) and their limited radius of dispersion, possess the proper qualities to render sufficiently unsafe large areas like those in which the reserves or the second line etc., take up their positions. Both these conditions, on the contrary, are fulfilled in full measure by the new German howitzer. Not without good reason has Russia increased its 5 field mortar regiments quite recently, or Italy sent light field mortar batteries to Tigré; other nations, for the same reasons, possess guns resembling howitzers in character to be used in the field;—the old howitzer, separated from the field artillery for many decenniums, had to re-establish its claim.

But, although in the course of the development of the various branches of the science of war certain phases recur, the Present does not seek guns of the howitzer character for use in field service with the same object in view as o old, but for the special purpose mentioned.

The *second* of the purposes of the new howitzer is the destruction of special targets of considerable resistance, such as hasty, semi-permanent and even permanent fortifications at great distances, which it accomplishes with great effect and in quite a satisfactory manner. Targets of this kind may include: earth walls, covered batteries, etc., in intrenched positions prepared for defense, and fortifications which may impede the march of an army. Examples of such fortifications are the forts constructed on an extensive scale, particularly on the French side, on all the railroad lines leading from the eastern border into France, as well as between the elements of the girdle of fortifications Verdun-Toul-Epinal-Belfort. This chain of forts in conjunction with the fortified camps lying between them, is intended to cover the French army in its advance to and assembly on the Maas and Mosel, and the attacker, therefore, will make every effort to interrupt this advance and obtain possession of these forts as quickly as possible. But for this purpose field guns are not sufficient, hence, with this object in view, it has become necessary to supply the German field army with light, easily transported, and effective siege guns, capable of rapidly destroying the walls, caponières and other cover so dextrously applied in these forts. These conditions are, however only partially fulfilled by certain calibers of the siege artillery; owing to their ballistic properties and slight mobility, the new howitzers, on the contrary meet all the requirements in the highest degree, and their introduction is therefore hailed with satisfaction. To properly fulfill the purpose for which they are designed care must be taken that they are held in readiness in sufficient numbers to be available at the desired time and place when required. Although their effect may not be such as to penetrate in a very short time the latest highly improved constructions in the best fortified places and forts, in powder and ammunition magazines, and in the bomb-proofs of smaller forts (Sperr-forts) where projectiles are charged, it is nevertheless quite sufficient to rapidly destroy all other parts of these fortifications. With a range of over 1¼ German miles (5 English miles) they fulfill satisfactorily the highest requirements of accuracy and effect, and will be, of course, very effective against an enemy in an intrenched position. They represent with their new improved projectiles a material excellent in every respect, and may be regarded as the climax of the material, excellent throughout, of the German foot artillery, while the introduction of a rapid-fire gun for the field artillery can be only a question of time, of means and of the action of other nations in this direction.

—*Allgemeine Schweizerische Militär-zeitung*, March 28, 1896.

FORTIFICATIONS.

The Fortifications of the Dardanelles.

The disturbances still continuing in Constantinople and other points of the Ottoman Empire, and which may possibly result in the *active* intervention of the great powers, especially England, as well as the recent reconnoissance of the Dardanelles fortifications made by the chief of staff of the military district of Odessa, General Tshichatshef, and the Russian military attaché at Athens, Colonel Kaluin, both reporting to the Sultan, direct public attention

once again to the important channel of the Dardanelles, to obtain the command of which is one of the most important political and strategical objects of Turkey.

The channel of the Dardanelles, which connects the sea of Marmora with the Aegean Sea, is about 75 km. (47 miles) long, on an average from 5—6 km. wide, but at the narrowest part only 1 km. (⅝ mile), and cuts deep down into the surrounding heights of the Taurian and the Balkan Peninsulas: it is everywhere navigable for war ships of any draught. Its fortifications are arranged in three groups. The first, on the south, lies on the southern points of the peninsula which limit the Gulf of Saros on the south. It consists of the new Dardenelles castles of Sedil-Bahr-Kalessi and Kum Kalessi. They are situated opposite each other at the southern entrance to the strait, the former on the European side, the latter on the Asiatic side, about 3,800 meters apart. Fort Sedil-Bahr-Kalessi is built in terraces rising one above the other; it was reconstructed in 1881 and armed with 70 guns, including 12 mortars. Both forts have been entirely rebuilt, but at present are only partially armed with Krupp guns, the remainder having been taken over to the fortifications of the Bosphorus, one strengthened by a separate earthwork of 16 guns, the other by one of 32 guns, so that the entrance to the Dardanelles is under the fire of about 160 guns altogether, to which will probably be added, in the event of war, as shown by the present preparations of the Porte, one or more systems of torpedoes, sunken ships, etc.

Some 500 meters north of Fort Sedil-Bahr-Kalessi lies the fortress of Paläocastro or Eskihissarlik-Tabia. This is said to be armed with a considerable number of guns, including six mortars, and, at a distance of 4,700 meters from Fort Kalessi, serves the same purpose, viz: the command of the strait. here about 5 km. (3 miles).

The second and third groups are located on the narrow portion of the strait between Kepes Burun and Kap Naghara, only 1 to 2 km. wide, which is capable of being commanded completely by means of rifled guns, although it is not fully defended by batteries. This is the most important portion of the strait. At Kepes Baru there have been traced out two projected batteries, of 12 and 29 guns respectively, and opposite them on the European shore the two 17-gun batteries of Baicoah, constituting the second group of the fortifications. Some 4,600 meters north of them, at the narrowest point of the Dardanelles, only 1 km. wide, is the third group of its fortifications, comprising the old castles Kilid-Bahr and Kaleh-Sultanich. They were built in 1,660 by Mahomed IV, and the so-called "Kemerliks," Turkish guns of large caliber, were afterwards placed in them; in their day these guns had a great reputation, and in the seventies of this century they were partly recast and partly sent away as presents to foreign lands, but about 11 remain in the Kilid-Bahr, among them the largest, Haidar-Baba, throwing a marble shot of 12 hundred-weight.

The old fortified castle of Kilid-Bahr is replaced to-day by a shore battery, and in place of the fortified camp of Kaleh-Sultanich the batteries of Pasha Tabiassi and Tshemenni Tabiassi, which are said to contain a considerable number of guns, among them 4 mortars, have been constructed. Both forts are situated opposite each other at a distance of about 1,400 meters, and Fort Kaleh Sultanich is protected against a land attack by a line of earthworks surrounding it on the neighboring heights.

After 1830 Sultan Mahmud II had the 36-gun battery of Namasquiah built

south of, and close to Kilid Bahr, and about 2 km. north of this castle the 13-gun batteries Degirmen-Burun-Tabiassi; moreover, on the European shore, he constructed Fort Boghassi and on the Asiatic Fort Naghara, which constitute the northern section of the third group of fortifications. The former is designed for 122 guns, the latter for 37 guns, including 4 mortars. Fort Naghara is built much more substantially than Fort Boghassi. The two forts are situated opposite each other at a distance of 2,200 meters, and take under their fire the narrowing of the Dardanelles at this point and the entrance to them from the Hellespont. The stretch of strait commanded by them is all the more important as rocks and shoals render navigation dangerous at this point, and ships are compelled to pass in single file, one behind the other.

About 5 km. south of Fort Boghassi Mahmud II also constructed the batteries of Sham Tabiassi or Maitos for 15 guns, 3 of which are mortars, and three kilometers south of Fort Naghara the Kosh-Burun-Tabiassi or Tekeh battery of 15 guns, 3 of which are mortars; 2 km. south of the last-named battery, the work of Medjidjieh-Tabiassi was constructed, in Sultan Abdul-Medjid's reign, with a view to enfilading the narrowest part of the Dardanelles.

While the previously mentioned projected second group of batteries is expected to take under fire the entrance to the straits from Tshanak Kalessi with a total of 58 guns, within the effective range of which there will, of course, be torpedo mines, etc., the third and most northerly group of the fortifications employs several hundred guns to rake the narrows of the Dardanelles and their northern entrance over a space 7 km. long and, on an average, 2 km. wide. In sum-total there are to be several hundred guns (including 48 mortars) for the defense of the important straits, a number, which, if actually in position, should, in conjunction with torpedo mines, which can be easily laid here, on account of the slow current—much slower than that of the Bosphorus—and active Turkish torpedo-boats, render the straits of the Dardanelles absolutely impassable for an enemy's fleet.

All the fortifications constructed in later years consist of strong earthworks, connected by telegraph lines with each other and with Constantinople, as well as by well-built roads. Since the year 1863, at the instigation ot the then English ambassador in Constantinople, Sir Henry Bulwers, the re-building of the Dardanelles fortifications, which had become comparatively worthless in consequence of the introduction of rifled guns and armored ships, was begun and continued, with many interruptions, up to the Russo-Turkish war of 1877.

The batteries Namasginah, Medshidje and Degirmen-Burun-Tabiassi, as well as Fort Naghara, have been finished so as to conform fully to the requirments of the present time, although not as yet to the action of the gun-cotton or melinite shells of today, which, with the exception of the French, are not yet carried by the world's fleets, although they are being tested.

Strong as the fortifications of the straits of the Dardanelles appear to be against a fleet attempting to pass through them towards Constantinople, yet, on the land side they are without special protection against an attack by an enemy who may have effected a landing on the Gallipolis peninsula. The Turkish government, therefore, intends to erect forts and shore batteries on the Gulf of Saros and on the shore opposite the island Imbros, and has already constructed a fort on the island of Tenedos. With a view to cutting off the peninsula against an attack from the south there are erected at its narrowest part, between the Gulf of Saros and the Sea of Marmora, the lines of Boulair, consisting of the forts Victoria, Napoleon and Sultanich, and designed for an

armament of some 50 Krupp position guns and a considerable number of Paixhan guns, and in the event of war are calculated for a garrison of 20,000 men with about 100 guns to defend them. They constitute a strong section to oppose the advance toward the north of an enemy who may have effected a landing on the peninsula.

The fortification of Gallipolis, which Wachs recommends, would hardly add much to the defensive strength of the peninsula, unless it is to receive a very strong garrison. The peninsula requires,—a fact which the Turks have recognized,—shore batteries and coast forts, but behind them at the proper distance troops must be stationed, which will be able to oppose promptly any landing force. The landing of small detachments by the enemy can serve no useful purpose, but the danger from the landing of strong forces ought to be recognized by the defenders (who are at home in their own waters), and proper steps taken, in plenty of time, so that the necessary measures, i. e., the occupation of the peninsula with sufficient forces, may be ordered betimes. The line of Boulair offers a sufficiently strong obstacle to serve as a defensive position and support.

But, just as the Bosphorus could not in former times present for any length of time a sufficient obstacle to the armies attacking Constantinople, so too the straits of the Dardanelles have been successfully crossed from the Asiatic to the European side, only once in recent times, to be sure, but a number of times in the past: for example, in ancient times the crossing of Xerxes, which is supposed to have taken place at Cape Naghara, and that of Alexander the Great; also in the middle ages that of the Turks in their first invasion of the Provinces of the Grecian Empire in the year 1356. In modern times Admiral Elphinstone, in the service of Russia, while engaged in the pursuit of two Turkish ships of the line, succeeded in passing the forts Sedil-Bahr and Kum-Kaleh with three ships of the line and four frigates in July 1770, and entered the straits of the Dardanelles. He went no farther than to Kepes-Burun, whereas his more fortunate successor, the British Admiral Duckworth, in February, 1807, succeeded in passing through the entire strait close up to Constantinople, without, however, being able to accomplish anything against that city. To-day, since there are absolutely no shore batteries or fortifications completed on its southern border, Constantinople would in such a case fall an easy prey to the bombardment of a hostile fleet. Besides its uncommonly strong fortifications, the straits of the Dardanelles are protected also by political treaties, since it is closed by the treaty of Paris of March 30, 1856, which the treaty of London of March 13, 1871, confirmed, to war ships of foreign nations, and can only be entered and passed by such war ships with the express permission of the Turkish government. Moreover, the commercial intercourse of foreign merchantmen on the Dardanelles is rendered difficult by special regulations and tolls, and as a protection against any violation thereof foreign mershantmen are never permitted to pass the narrow point of the straits at Tshanak-Kalessi by night. Should an attacker, however, succeed in forcing the straits, and obtain control of the Sea of Marmora with his fleet by defeating the Turkish fleet, which would not be a very difficult matter at the present time, the metropolis of Turkey will fall an easy prize into his hands; and the same may be said of an attacker, who succeeds in advancing victorious from Asia Minor towards Skutari, since this suburb of Constantinople has at present no fortifications whatever, on the other hand, with the girdle of advanced provisional works or forts, as General Brialmont

intends to construct them, with 6 armored turrets, it will serve very well as a protection for the metropolis.

—*Allgemeine Schweizerische Militär-Zeitung*, October 17, 1896.

[Translated by J. P. W.]

WAR SHIPS AND TORPEDO BOATS.

Torpedo Boat Destroyer "Entre Rios."

On page 430 (*Engineering*) we illustrate one of four torpedo-boat destroyers which Messrs. Yarrow and Co., of poplar, have recently constructed to the order of the Government of the Argentine Republic. In our issue of May 22 of this year (see vol. lxi., page 686), we noticed the launch of one of these vessels. Again, in our issue of July 24 last, we gave some details of a trial made with the *Santa Fé*, a sister vessel to that we now illustrate. It is thus only necessary to repeat the leading elements of design.

The vessel is 190 ft. 8 in. long by 19 ft. 6 in. wide, her depth amidships being 12 ft. The machinery consists of two sets of triple expansion engines of the type usually placed in craft of this nature. The cylinders are 18 in., 26 in., and 39½ in. in diameter by 18 in. stroke. There are six boilers of the Yarrow water-tube type. The weight of each of these boilers is 6¾ tons, with water and fittings, and they are designed to supply steam for 4000 indicated horse-power, which is about the power developed at full speed. The propellers are of manganese bronze, each with three blades. The general arrangement of the cabins differs from that followed in the English service, chiefly in the fact that the officers have the forward part of the vessel, where there is least vibration and noise, assigned to their use. The officers' cabins and mess rooms are placed as near amidships as the engines will permit. The petty officers have quarters aft, and the crew, as usual, are berthed right forward.

As previously stated in our issue of May 22, the leading feature in the design is the armor by which the middle length is protected. This entirely surrounds the machinery space, there being ½ in. thwart-ship bulkheads, as well as the side armor. This, of course, adds considerably to the weight, and, as a consequence, detracts from speed. We briefly discussed the policy of armoring these little boats in our former issue. It may be said that such very limited practical experience as exists points favorably towards protection, as the armored boat *Kotaka*, built by Messrs. Yarrow for the Japanese about 11 years ago, led two important torpedo attacks, and came out comparatively unharmed, whilst the unarmored boats suffered severely.

Our illustration is interesting as showing the boat with her armament in place. The piece on the conning tower is a 14-pounder quick-firing gun, whilst there are three 6-pounder and two Maxim-Nordenfeldt machine guns on deck. There is one 18-in. torpedo tube forward and two 18-in. swivel torpedo tubes on deck. The bunkers will hold 80 tons of coal, which will give approximately 2500 miles radius of action at about 10 knots speed.

The *Entre Rios* was taken for her official trial on September 1. The guaranteed speed with load of 35 tons was 26 knots, which was exceeded by ¼ knot.

The trial was conducted in the presence of Captain Diaz, Mr. Hughes, Lieutenant Grierson, and Lieutenant Barbara, all of the Argentine Navy.

The *Entre Rios* is at the present time being fitted out for making the passage out to Buenos Ayres under her own steam. Her sister—the *Santa Fé*—has already left, and may possibly have encountered the full force of the

heavy gales experienced lately. Little anxiety has been felt for her safety, as these little craft, long and low as they are, prove admirable sea-boats. Their light yet strong hull construction makes them exceedingly buoyant, whilst the great reserve of power, admirable maneuvering qualities, and, above all, the stress the engines will stand without danger, enable them to go through with impunity an ordeal that would severely test far more imposing looking craft.

—*Engineering*, October 2, 1896.

BOOK NOTICES.

Life of Napoleon Bonaparte by William Milligan Sloane, Ph. D., Professor of History in Princeton University. Vol. I. Pp. 283. New York, The Century Co., 1896. Complete in four volumes, Cloth $7.00, Half Morocco $8.00 per volume, or in twenty-two parts, issued monthly, $1.00 each.

"As there is no study more delightful than that of history, so is there none more vitally necessary to the citizen of a free state. The constitution of a democratic republic especially, assuming as an indispensable condition of its working that every citizen shall take an intelligent interest in public affairs, imposes the study of history as a duty incumbent upon all. It is impossible to form a correct judgment of present circumstances without the means of comparison with the past supplied by a knowledge of history."

C. K. ADAMS.

What more brilliant period, either for the general reader or the military student than that following the great French Revolution—the culmination of the democratic spirit of freedom begun in the Reformation—and covered by the life of the greatest master of strategy the world has ever seen, Napoleon Bonaparte? Ten years ago there was no work on the great Corsican or any portion of his history that was entirely free from prejudice. Up to that time the reading world had to choose between the glowing accounts of the man and his actions furnished by the French writers, or the intensely bitter and spiteful views presented by the English authors. "Until within a very recent period it seemed that no man could discuss him or his time without manifesting such strong personal feeling as to vitiate his judgment and conclusions."

In March, 1888, appeared Ropes' account of Waterloo in *Scribner's Magazine*, the first dispassionate investigation of that campaign accessible to the general reader in America or England, and since that time fair views on the subject of the first Napoleon have become public property, several of England's greatest soldiers, notably Viscount Wolseley and Sir Evelyn Wood, being among the first to obtain for themselves and give to the world a calm, clear, accurate and unbiassed version of at least portions of his career. During the past quarter century students in all countries have examined the records which have become accessible, in a scientific spirit of perfect fairness, and the time has at last arrived when we may expect such a history of the life, the actions and the character of the great Napoleon as will stand the test of time. In this work before us the expectation is realized.

Professor Sloane has devoted many years of his life to this special study, and building as he did on the solid foundation of a most thorough knowledge of France and her history, obtaining his finest materials for the structure from mines but recently opened, and perfecting his work in conception and accuracy of detail by personal visits to the scenes of action, he has placed before the world a magnificent monument of "the most tragic figure on the stage of modern history."

The illustrations include reproductions of paintings, many in color, by some of the most eminent artists,—Detaille, Meissonier, David, Myrbach, Gérome, Grolleron,—besides illustrative designs and drawings of buildings and places

made especially for this work. The exceeding beauty of this part of the book inspires admiration in lovers of art, and the collection of pictures constitutes practically a history of art so far as it relates to Napoleon and his times. We would not have one of these pictures omitted: although the text is *history* there is no reason why its pages should not be beautified by art; our love of the *True* need not necessarily suffer on account of our love of the *Beautiful*, but should rather be enhanced and completed by it, provided we put the proper interpretation on it.

The first volume reaches only to the fall of Venice in 1797, fully one-half being devoted to the early portion of Napoleon's life, about which little has been heretofore made public. The material for this new matter the author found in the archives of the French Foreign Office, in Florence, and in the British Museum. In the preface he states: "At the close of the book will be found a short account of the papers of Bonaparte's boyhood and youth which the author has read, and of the portions of the French and English archives which were generouslv put at his disposal, together with a short though reasonably complete bibliography of the published books and papers which really have scientific value." The citation of his authorities for the great amount of new matter introduced was, of course, essential for the satisfaction of the reading public, but the complete bibliography, coming as it does from the pen of one so thoroughly capable of judging of the value of a book on this subject, will be of inestimable value.

This is, it must be remembered, a life of Napoleon, and therefore seeks to present the *man*, in all his various aspects,—"the revolution queller, the burgher sovereign, the imperial democrat, the supreme captain, the civil reformer, the victim of circumstances which his soaring ambition used but which his unrivalled prowess could not control",—hence, the military student must not expect to study the art of war therein, but will find there abundant valuable matter to assist him in such study. Motives and causes are set forth in excellent form, and with a freshness and vigor that is extremely convincing. The author does not always exhibit the power to furnish a graphic picture of a campaign easy of general comprehension, but there are many marked exceptions to this, and in the Campaign of 1814 he rises to the occasion and paints for us a vivid picture of the brilliant movements of the great master of strategy in words that have all the inspiring energy and force of the actions themselves.

We have endeavored to give a general idea of the purpose, scope and character of this great work, and propose to supplement this general notice with others bringing out in more detail the style of the author and the manner in which he has performed his task.

J. P. W.

Gustavus Adolphus. A history of the Art of War from its revival after the Middle Ages to the end of the Spanish Succession War, with a detailed account of the campaigns of the great Swede, and of the most famous campaigns of Turenne, Condé, Eugene and Marlborough. By Theodore Ayrault Dodge, Brevet Lieutenant-Colonel, United States Army. Boston and New York; Houghton, Mifflin & Co. Pp. 846. $5.00.

This is the fourth of the series of great soldiers, whose actions marked epochs in the history of the Art of War,—Alexander, Hannibal, Cæsar, Gustavus Adolphus,—in which the author traces the developments in the successive stages of this art.

"That the immense gap of sixteen and a half centuries which intervenes between the last campaign of Julius Cæsar and the first campaign of Gustavus Adolphus is left almost untouched, must be justified by once more reminding the reader that the author has made no attempt to cover the history of war, but seeks only to indicate the origin and growth of what to-day we call the art of war."

The volume opens with a brief sketch of the era of Cavalry, 378-1315, and in summing up the author remarks: "The Crusades were the typical work of the mailed knight; and as this warrior made practically no impress on the art of war, so the Crusades teach us no useful lessons." The reappearance of infantry, 1315-1500, re-established the value of foot, first by means of the pike and long-bow, and later by the musket. The cavalry, in the sixteenth century, was marshalled in solid columns, while the foot was drawn up in heavy squares, called *battalia* or *battles*, placed in one continuous line, or checkerwise, or in concave order, the depth of each about thirty to forty men; the foot stood in the center, the cavalry on the flanks; the artillery was placed in batteries at commanding points, the horses or oxen which dragged it being sent to the rear.

"Sweden was the first country in Europe which built up for herself a regular and at the same time national military organization." This Gustavus inherited and perfected. He reduced the size of regiments, gradually decreased the number of pikemen and increased the musketeers in proportion, and by lightening the armor made his infantry more mobile. The cavalry he did not improve much, but in its charges he taught it to ride at a gallop. "But there was no question as to the superiority of Swedish artillery. * * * Gustavus used his cannon in masses as well as with regiments, and the excellence of his artillery largely contributed to his successes."

"The chief improvement in the tactical formation, and this was brought about by the introduction of gunpowder, lay in the lessening of the depth of the file; and yet it is curious how old-fashioned soldiers like Tilly stuck to their deep *battles* when artillery was becoming effective."

The history of Gustavus, from the date of his birth in 1594 through the years of his childhood and youth, his first service in Denmark in 1611, his Russian campaign in 1615, and his magnificent career in Germany in the Thirty Years' War are told with immense patience in great detail, and yet with an interest that holds the reader's attention throughout the many pages devoted to the great Swede.

After fourteen months of cautious advance in Germany, from the Baltic to Leipzig, with many actions of more or less importance, Gustavus secured his position by the decisive battle of Breitenfeld (1631), "the first great engagement in which the modern tactics of mobility, of which Gustavus Adolphus was the originator and exponent, were opposed to the Middle Ages tactics of weight." Tilly, who had never lost a great battle, was completely defeated. In another year the "Snow King" had penetrated as far as the Danube, and once more made sure of the ground he had gained at the battle of Lützen, where he defeated Wallenstein and destroyed the last army of the Emperor. But the career of the great soldier ended on this his most glorious field, In attempting to re-establish order in his right wing after its advance he learned of the retreat of his center, and at once headed the Småland cavalry regiment, and with his usual impetuosity galloped over to the aid of his hard-pressed infantry. In his over-eagerness, and followed only by three

companions, he galloped far ahead of his column and was killed by a strong party of imperial cuirassiers, who rode down upon him by simple accident.

"Gustavus belongs to the six Great Captains because of his careful method and his boldness combined; if either quality won him more than the other, it was his scrupulous care in doing well whatever he undertook to do."

The second half of the volume discusses the careers of the captains who followed in the footsteps of the king of Sweden and completed the developments in the art of war which he so well began: Cromwell, Turenne, Condé, Montecuculi, Prince Eugene, Marlborough and Charles XII.

If the present volume seems a little behind the preceding ones of this valuable series in point of arrangement and interest, it is because of the immense task the author set himself in attempting to cover so great an extent of time and condense the entire matter into a single volume. It is a stupendous piece of work, and considering all the difficulties the task was remarkably well done.

To the military student the author's estimates of the characters of the leaders are of great value, the strategical and tactical movements are correctly and clearly adjudged, and the developments in the art of war in its largest sense (strategy, tactics, arms, supply, etc.) are brought out very distinctly and in a masterly way.

The work is illustrated with 237 charts, maps, plans of battles and tactical maneuvers, cuts of uniforms, arms, and weapons, which add to the artistic as well as professional value of the book. The maps are generally all that can be desired, and the smaller maps are excellent, but those of the large fields of operations are sometimes indistinct, are not always convenient for reference, and are not on a par with the rest of the volume in character or quality.

Colonel Dodge's series of Great Captains has been accepted as practically authoritative on the subject of the history of the art of war, and this fourth volume is unique in discussing the period it covers from a point of view which has not heretofore been attempted, making it in that way doubly valuable.

J. P. W.

From Manassas to Appomattox. Memoirs of the Civil War in America. By James Longstreet, Lieutenant-General Confederate Army. Philadelphia: J. B. Lippincott Company. 1896. Pp. 698.

It is generally conceded that the French are pre-eminently the great writers of *memoirs*, but certainly the leading spirits of our Civil War have furnished very praiseworthy additions to this class of literature, and the latest of these, General Longstreet's, holds a high place among them. There is a depth of feeling, a sincerity, a strength of conviction evinced in the pages of this book that carries us along, in spite of ourselves at times, and makes us feel the truth of the statements and the honesty of purpose of the man, and in the end we must admire and even love Lee's "old war-horse." We cannot help wishing, that for his own sake, he had been occasionally a little less grandly true to principle, a little more gently conciliatory with those who allowed personal feelings to cloud their sense of justice, yet we cannot but admire his frank, outspoken, fearless and vigorous defense of those whom he considered slighted or neglected. There is a humanheartedness in all these pages that lends a decided charm to the book, we feel that we are in the author's confidence, and he is telling us his story as he feels it. It is to be regretted, perhaps, that this work appears so late, after nearly all the principal actors have

passed away, since its statements cannot now be controverted by those most nearly concerned, still, the fact of its having been so long delayed also carries with it its advantages. The explanation of this delay is found in the preface to the book: General Longstreet was under the impression that General Lee would write the story of the campaigns of the Army of Northern Virginia, but he gave up the work, and then Longstreet took it up.

"It is not my purpose," he says, "to philosophize upon the war, but I cannot refrain from expressing my profound thankfulness that Providence has spared me till such time as I can see the asperities of the great conflict softened, its passions entering upon the sleep of oblivion, only its nobler—if less immediate—results springing into virile and vast life. I believe there is today, *because of the war*, a broader and deeper patriotism in all Americans. * * * "The spirit in which this work has been conceived, and in which I have conscientiously labored to carry it out, is one of sincerity and fairness."

The first chapter of the work gives us a brief account of the author's birth and ancestry, his school-boy days, his appointment to the Military Academy at West Point, where he graduated in 1842, his early life in the army and finally his services in the Mexican War. He was associated at West Point during his four years there with many men who became prominent in the war: Beauregard, McDowell, Bragg, Hardee, I. I. Stevens, Halleck, W. T. Sherman, Thomas, Ewell, N. Lyon, J. F. Reynolds, Newton, Eustis, Rosecrans, Pope, D. H. Hill, A. P. Stewart, B. S. Alexander and others.

The story of the Civil War is then taken up and continued with ever increasing interest as the end draws near. After the many accounts of the war which have appeared, the principal interest of this latest volume of course, centers about the points of difference from the older stories, and here we find plenty of readable and important matter, but before proceeding to illustrate these points we would like to call attention in passing, to the advantages possessed by the side that has the best artillery even in wooded and covered country as exemplified in the battle of Seven Pines, or Fair Oaks.

Turning now to Lee's first campaign against McClellan at Mechanicsville we find some new data for judging of Stonewall Jackson's character. Lee's plan was "for General Jackson to march down (from the valley) and attack McClellan's rear, while he made simultaneous attack upon his front." Jackson himself appointed the morning of the 26th for the attack. After three o'clock in the afternoon "Jackson came up, marched by the fight without giving attention, and went into camp at Hundley's Corner, half a mile in rear of the enemy's position of contention." In his critical review of the events of the campaign the author remarks: "If, instead of going into camp at Hundley's Corner on the afternoon of the 26th of June, he had filed to his right behind the Fifth Corps, he would have had it surrounded by fifty thousand men beyond the reach of succor." And in his remarks on the second Bull Run campaign he says of him: "As a leader he was fine; as a wheelhorse he was not always just to himself. He was fond of the picturesque."

In regard to the cavalry in this campaign he has some severe things to say: "A cursory review of the campaign reveals the pleasure ride of General Fitzhugh Lee by Louisa Court-House as most unseasonable. He lost the fruits of our summer's work, and lost the southern cause. * * * If the march had been made as appointed * * * we could have reached Alexandria and Washington before the landing of the first detachment of the Army of the Potomac at Alexandria on the 24th."

In the Maryland campaign we find that General Longstreet begins to feel confidence in his judgment as a soldier and strategist, and he illustrates this by his firmly opposing Lee's great blunder in that campaign,—the move on Harper's Ferry. His references to McClellan are worth noting:

Speaking of the information which he had on the afternoon of September 13, 1862, he says: "Under similar circumstances General Scott, or General Taylor, or General Worth would have put the columns at the base of South Mountain before night, and would have passed the unguarded gaps before the sun's rays of next morning could have lighted their eastern slopes;" and of the events of the 14th he says: "had the battle been held in wait for McClellan, his well-known habit of careful reconnoissance would have consumed the balance of the day;" finally, speaking of the Confederates: "That the disaster was not overwhelming they have to thank the plodding methods of the Union Commander."

In the spring of 1863 Longstreet proposed to relieve Vicksburg by sending Johnston from Jackson to reinforce Bragg, at the same time two of his own divisions then marching to join Lee,--the very plan afterwards attempted when too late - but Lee preferred his plan of invading the northern soil. Longstreet then suggested that "we should work so as to force the enemy to attack us," a plan to which Lee readily assented, but when they struck the Federal army at Gettysburg and Longstreet proposed filing around their left and securing good ground between them and their capital, he preferred to attack. Every page of the account of Gettysburg teems with interest, but we have space only for a few remarks. When Lee proposed Picketts' charge and stated the strength of the attacking column as fifteen thousand, Longstreet expressed the opinion that "the fifteen thousand men who could make successful assault over that field had never been arrayed for battle." When the time to order the charge came "Pickett said, 'General, shall I advance?' The effort to speak the order failed, and I could only indicate it by an affirmative bow."

The interest of the narrative increases as we approach the end, Longstreet's own growth as a soldier is as evident as the incapacity of many in high authority about him, and his military criticisms are incisive and just.

It is the finest story of the war from the Southern side and the best piece of military criticism on the operations of the war that has thus far appeared.

J. P. W.

François-Séverin Marceau, 1769-1796. By Captain T. G. Johnson, I. S. C. The Macmillan Company, 66 Fifth Avenue, New York. 1896. Pp. 341. Price $2.00.

This interesting biography of a great and good man, who lived his short life in a cruel age of selfishness, and yet preserved his purity of heart, his singleness and tenacity of purpose, his patriotism and his humanity, is as refreshing and fascinating as a good, healthy novel. When we have finished the book we feel that we *know* Marceau as we know Colonel Newcomb or David Copperfield; the author has performed his task excellently well in that respect.

Marceau was born at Chartres the same year as Napoleon, 1769, and the inscription on his monument there sums up his career briefly thus: *A soldier at 16 years, a general at 23, he died at the age of 27!* He died at the very time that Napoleon opened his brilliant career.

"The Revolution," says Victor Hugo, "by the side of youthful figures of giants, such as Danton, Saint-Just, and Robespierre, has young ideal figures,

like Hoche and Marceau." Marceau must have been a very lovable character indeed, for we find him inspiring affection in men of such different mould as Lafayette, Dillon, the delegate Bourbotte, Kléber, Jourdan, and even his adversary, the Austrian General Kray.

The military events of the compaigns are clearly and graphically presented, and are well worthy of study; the part which Marceau took in them is told with fairness and justice and the entire story depicts his character in a wonderfully clear and vivid manner; we are kept continually in sympathy with the thoughts and feelings of the *man*. Interwoven with this picture of the soldier and the man we have the sad and tender story of his friendships and his love, and when we close the book we feel all the better in that we have made the acquaintance of one more good and true man, who, by his grand example, will help us all to do *our* duty, under trying and discouraging circumstances, even as he did his.

He was unfortunate in his early friendships. Lafayette, on whose staff he had served, deserted to the enemy's lines. Dillon, to whom Marceau was much attached, was guillotined,—"I became intimate with this general," he says in his diary; "he certainly had more talents than manners, but I endeavored to profit by the former to the best of my ability." Biron, to whom he had become even more closely attached, shared the fate of Dillon;—Marceau says of him: "His solicitude for me was that of a father." Such associations naturally led to his being suspected, and it was not long before he was arrested and tried, but he was finally acquitted, Bourbotte, the public prosecutor, abstaining from voting. Not long after he gained Bourbotte for a life-long friend.

"He was proceeding across the meadows of Varrains when he saw a group of peasants around a prisoner whom, in the heat of victory, they were threatening to despatch. Marceau charged with his handful of cuirassiers and put to flight the soldiers of La Rochejaquelein taken unawares. He rescued the prisoner, who was wounded, and wore the tri-colored scarf of a delegate of the National Convention, and whom Marceau now recognized to be none other than his implacable foe, the deputy Bourbotte. Hastily dismounting he offered him his horse and assisted him into the saddle, saying, 'It is better that I, a soldier, should die than that the enemy should have the satisfaction of putting to death a representative of the people.' The peasants returned, and Bourbotte's retreat was with difficulty covered by the affrighted cuirassiers, who heard cries of despair and treachery all around them." From this time on his promotion was rapid and his deeds were fully recognized.

The last scene of all is indeed a sad picture: "A party of grenadiers carried him, accompanied by loud expressions of grief as he passed through the columns of the troops he had commanded and those of Bernadotte's division. * * * The road was long and difficult and the heat excessive, but the grenadiers who carried him refused to be relieved. * * * It was on this (Altenkirchen) bridge that Jourdan with his staff and several other generals met Marceau. All were profoundly affected at the sight. Jourdan, and the other officers who knew him, shed tears, and on the countenances of all could be read the grief that speaks loudest in silence. * * * The enemy meanwhile continued to advance, and Jourdan was obliged, however reluctantly, to leave his friend and those who remained in attendance on him to the generosity of the enemy. * * * Most of the general officers and some others of the Imperial army came to see him as they passed through

Altenkirchen, as a mark at once of their esteem and their sympathy. But nothing was more touching than the attentions of the veteran, General Kray. * * * In his grief he took the dying man's hand in his and pressed it to his heart, and, while he sought to console those who stood mournfully around, tears ran down his own cheeks as he bent his gray head over the trembling pulseless hand. At 6 o'clock on the morning of the 21st of September his life was merged for ever in that which we call death."

"Marceau's body had now to be removed to Coblentz. At Altenkirchen there was almost a struggle between the French and the Austrians for the honor of conveying it as far as Neuwied. The wishes of the latter prevailed, and a detachment of Branco's hussars formed the escort, and the Austrian officers made all the preparations. It was about this time that Prince Charles entered the chamber of death. He stood for a moment gazing on the face of of his adversary. They were both of the same age. He knelt at his bedside for awhile, then, shading his eyes with his hand, left the room in silence."

J. P. W.

Cavalry in the Waterloo Campaign, by General Sir Evelyn Wood, V. C. Boston. Roberts Brothers, 1896. Pp. 203.

A bright, breezy, dashing and generous account of the deeds of the cavalry on both sides at Waterloo, by one who evidently studied with care all the later literature bearing on the subject, and is himself an authority on what concerns cavalry, and can therefore appreciate tactical sense as well as personal bravery.

This is the third volume of reprints of important articles that appeared in the pages of the *Pall Mall Magazine*, and the cavalry branch of the service is fortunate in having the story painted by such a master hand. The cavalry officer, who believes in his arm, will find ample confirmation of his views in these pages, and can look forward with satisfaction to the future of that arm.

After a brief account of the organization of the French army and a description of the French cavalry leaders, the author takes up the thread of the story.

The incapacity of the staff service was early illustrated:

The delay in the concentration on the Sambre at Charleroi was due to the fact that the orderly officer with the order directing Vandamme to move at 3 a.m., did not find him. and Soult omitted to inform Vandamme that he was to pass under Grouchy's orders, so that instead of starting at 3 a.m. he did not start till 7 a.m. (delaying also the Imperial Guard which was to follow him), and when Grouchy ordered him to advance and press the retreat of the Prussians, Vandamme refused to take orders from him.

The commanders are freely and fairly criticised:

"If Ney had followed up the Nassau battalion immediately, there is little or no doubt that he might have occupied Quartre Bras without difficulty."

In regard to Wellington's delay in sending orders he says:

"I shall show, further on, the grave risks which were incurred by the delay in sending out the orders. This might have been avoided to some extent if Wellington had proceeded himself on the 14th to Nivelles, about which town the chief portion of the infantry of the 1st (or left) army corps was cantoned. There can be little doubt that the Duke should have done this, and that Picton's (Reserve) division and the Brunswick troops should have been moved up to Genappe earlier." * * *

"The cavalry, for convenience of forage and supply, had been cantoned by brigades, and in some cases by regiments, on the Dender river. The excuse

of the French advance being unexpected has been alleged as the reason for not having formed the seven brigades into divisions, but this is inadmissible, and it was the cause of the loss of many lives on the 18th of June."

D'Erlon's movements are thus summed up:

"There can be no question of the propriety of D'Erlon's conduct up to the moment of the arrival of General Delcambre, who ordered him to rejoin Ney at Quartre Bras. Some officers argue that on receipt of this positive order D'Erlon had no alternative but to obey; but this view is, I think, unsound. The measure of obedience to be exacted from a junior officer, and from one high in command is different."

Of course, the work is mainly devoted to the movements of the mounted services in this campaign, and we will now turn our attention to them. At Ligny, D'Erlon's wanderings prevented the use of the cavalry until twilight, but about sunset Excelmans and Milhaud did some fine work. "Nobody has criticised more plainly the failure of the Prussian cavalry than German authors." At Quartre Bras, Kellerman's attack, begun so gloriously and ending so disastrously, is vividly described. "Marmont puts Kellerman as the first of the only three French cavalry leaders whom twenty years of war produced."

In the introduction to the battle of Waterloo the author says:

"Ney, who led the cavalry as well as the infantry charges on June 18th, however brave, however experienced in war, was as regards cavalry, but a poor substitute for Murat, and, as will be seen in my story, would not listen to Kellerman, who was far superior to him as a leader of Horse."

The attacks at Waterloo are divided into five phases, those in which the cavalry took part being described in a truly masterly way. The interesting details which the author has interwoven with his description of the tactical movements give color and life to the picture, and add to its value as a tactical study, impressing the reader with the fact that the cold diagrams of subdivisions represent masses of living, breathing and acting human beings.

The descriptions of deeds of personal daring are many. At Quatre Bras, when Kellerman's cuirasssiers rode through the 69th, "Major Lindsay, Lieutenant Pigot, and Mr. Clarke, a volunteer, resisted desperately. The last named officer killed three Cuirassiers, and although himself wounded in twenty-two places by sabre cuts, preserved the color he was carrying."

At Waterloo, although in some portions of the field no quarter was given, Millhaud's Cuirassiers acted differently. "One of them galloped at a trumpeter with the intention of running him through, but, seeing how young the boy was, dropped the point of his sword and passed on."

"Major Poten of the King's German Legion, having lost his right arm in the Peninsula, was attended by two non-commissioned officers at Waterloo, who were detailed to ride one on either side of him. In the confusion of a charge during the afternoon they were, however, separated from the major, and he was attacked by a cuirassier, who had already raised his sword when the major, turning his horse, showed that he had no right arm, and the Frenchman, dropping the point of his sword to 'the salute,' rode away."

The tactical points discussed in the course of the work we have not referred to as they require careful reading and study by those interested, to whom we heartily recommend this thorough discussion of the operations of the mounted branches.

J. P. W.

Memoires du Général Cte. de Saint-Chamans, ancien Aide de Camp du Maréchal Soult. 1802-1832. Paris: E. Plon, Nourrit et Cie. 1896. Pp. 542. Fr. 7.50.

The most brilliant and fascinating epoch for the soldier is still that of the first Napoleon, and the memoirs of the Count de Saint-Chamans have a special value in the history of this epoch, because he lived through the entire period, was always at heart a legitimist, occupied prominent positions and told his story simply and clearly.

He was a child during the horrors of the first French Revolution, a young man when Napoleon took the reins of government in his hands, a mature man at the time of the restoration and an old man at the second Revolution. It would be difficult to find a period of greater and more varied events than that extending from 1789 to 1830, the period through which he lived, consequently there can be no doubt of the *interest* attaching to these memoirs.

Born in Paris in 1781, he entered the service as a private in 1801 and received his commission as second lieutenant in 1803. His first service was in Piedmont, but in 1804 Soult took him on his staff and then began his interesting experiences. In beginning his narrative he says, "I do not intend to write the history of my time, but merely to narrate truthfully the events which I witnessed and which appeared to me worthy of notice; I do not pretend to tell the whole truth, but I will, at least, tell nothing but the truth."

He was present at Memmingen and Ulm, and at Austerlitz was promoted to captain and decorated with the Legion of Honor: and one of the most affecting scenes in the book is that describing the effect of the rebuke which Napoleon administered to the regiment which lost its eagle at Austerlitz: it was taken down word for word at the time, "not even the errors in French construction being corrected":

"Where is your eagle? (A moment of silence.) You are the only regiment of the French army to which I can put that question! * * * I have just seen many regiments which have hardly any officers or soldiers left in their ranks; but they have kept their flag, their honor; and you,—your companies are still full, and yet I cannot find my eagle in your ranks!'"

These words were uttered with so much vehemence that the effect on all who heard him was quite impossible to describe: "I know very well that, for my own part, it made my flesh creep, I felt a cold perspiration all over me, and tears rolled down my cheeks."

After Jena and Eylau the Conte de Chamans was appointed *chef d' escadron*, and towards the end of 1807 was sent on a diplomatic mission to St. Petersburg, the account of which is very interesting.

In 1808 Soult was ordered to Spain and the Count, his aid, accompanied him thither. There was soon work enough on hand and the memoirs gather importance and interest. After the battle of Corogne, where Sir John Moore was killed, the state of affairs is thus described:

"The environs of Corogne presented a sad spectacle; besides their dead and wounded, which they had abandoned, the English, for want of time, not being able to embark their horses, had killed them all in order to prevent their falling into our hands, and on the shore whole squadrons of fine horses lay stretched out, almost in order of battle. They had also abandoned several pieces of artillery and blew up a great powder magazine located outside the town."

He gives us an insight into Soult's character and freely accuses him of

disloyalty to the Emperor while in Portugal and intriguing for the throne of that country.

After serving with Soult through the battle of Albuera he was promoted to colonel of a regiment of dragoons, but at the end of the year, 1811, he was transferred to a regiment of chasseurs, and in 1812 he took part in the campaign in Russia. In the retreat on Lepel after Polotsk he was wounded and had to return to France, and did not rejoin his regiment until July 1, 1813. He was present at the battles of Reichenbach and Leipsic, and at the latter was again severely wounded and taken prisoner, being detained in Germany until late in February, 1814, when he entered France on parole, and was present during the defense of that city and the entry of the allied soverigns.

Count Saint-Chamans served for a time as aid to General Dupont, minister of war under the provisional government, but the intrigues at court disgusted him and he applied for a regiment.

The account of the state of affairs in Paris when it was known that Napoleon was on his way there, is told with perfect simplicity and directness, all the more valuable as he was not an enthusiast. Indeed, Colonel Saint-Chamans tried hard to keep his regiment loyal but could not stem the tide of popular enthusiasm for the Emperor. He retired from active service during the Hundred Days.

In September, 1815, he was appointed colonel of the dragoon regiment of the Royal Guards and field marshal. In 1821 he was appointed gentleman of the chamber to his majesty. His duties now brought him in close contact with the king and his court and he gives us a graphic account of the inner life at the Tuileries.

In 1822 he was made inspector of cavalry and served in the Pyrenees in that year and in 1823, commanding finally a brigade. He was present in Paris during the troubles of 1830 and was retired in 1831, when his memoirs end, although he did not die until 1848.

Personally, Count Saint-Chamans was a man of great strength of character, honorable, reliable and with firm decision, but entirely lacking in enthusiasm or imagination. Although inspector of cavalry at the age of 41, he is still dissatisfied. Indeed, throughout his memoirs he shows a feeling of discontent, sometimes very bitter, and continually complains that he does not get his deserts. But one cannot help admiring his conduct during the Hundred Days and in the uprising in 1830.

The historical value of this work rests on the fact that it is a record of things seen, written at the time they happened. This fact also adds value to his references to the great personages of the time, but above all to his presentation of the *spirit* of the times, as illustrated in the life in camp and in garrison, on the field and in the palace.

J. P. W.

The Naval Annual, 1896. T. A. Brassey. Portsmouth, England. J. Griffin & Co., 2, The Hard. Pp. 440. 12 shillings and 6 pence.

This valuable publication is once more before the pubic and with better material than ever before.

"It is ten years," says the Preface, "since the first *Naval Annual* was published. The originator of the work has been called by public duties to our Australian colonies, but it is the intention of his son to carry on the work to the best of his ability and on his own responsibility. It was Lord Brassey's aim to collect in a convenient form reliable information as regards our own

and foreign navies, and to make the *Naval Annual* a record of the naval events of the year. It was designed mainly for the use of naval officers, and for that reason the price has been kept at an unremunerative figure."

The work is divided into four parts. Part I containing a number of excellent papers on war ships, Part II a series of Tables and Plans relating to ships, Part III essays on armor and ordnance, and Part IV Estimates. The most interesting papers in Part I are those giving an account of the progress of the British navy (Brassey) and of Foreign navies (E. Weyl), and—a new feature in the *Annual*—the detailed description of the material and personnel of the French navy (E. Weyl) and the Italian navy (Jack la Bolina). Other articles of special interest are British and Foreign warship construction (Orde Browne and Brassey) and The Value of Torpedo-boats in War Time (Commander Bacon R. N.). From the last-mentioned we quote the following:

"It is safe to assume that in the future attacks on harbors will only be undertaken by boats accompanied by a larger vessel, for either of two reasons. If the harbor is within the easy reach of a torpedo-boat station, it is only reasonable to assume that in these days it will be defended by breakwaters, whose gap would be closed by a gate boom. A heavy vessel would therefore be required to break away the boom. If, on the other hand the port is undefended, ships will not use it unless out of range of ordinary torpedo-boat night attack, in which case a protecting vessel will be of advantage to the boat during the hours of daylight of the cruise. It may well be worth the loan of such a vessel, on occasions to attack a fleet sheltering in a harbor, protected by mines and batteries from a hostile fleet, yet open to torpedo-boat attack; attacks of this nature will be all the more deadly from being unexpected, so that the further the distance of a raid, the more likely is the enemy to be unprepared. Again, occasion might arise when it would be worth the risk to an old vessel of clearing away a boom, to open a fleet to the flood of a torpedo-boat attack. Such a ship would clear away boat mines, and any other obstructions, with but little inconvenience to herself, but in turn would have navigation difficulties, torpedo-boats, batteries and mines to contend with."

The tables of Part II include an alphabetical list of British and Foreign armored and unarmored ships, giving their construction, dimensions, cost, armor, armament, speed and coal capacity of bunkers; a comparative statement showing expenditure of construction of new vessels in England and France; and comparative tables of the effective ships of England, France, Germany, Italy and Russia. Part II also contains 97 plates representing the most important of the new vessels of all nations. "With regard to these it may be observed that for some years past, in order to secure accuracy, no illustration has been published in the *Naval Annual* unless we have previously obtained a photograph of the ship to be illustrated from standard naval photographers or official sources."

The work as a whole is well worthy of its reputation as a standard authority. To the naval officer it is almost indispensable, and to the artillery officer it will be quite as valuable in time of war, and in time of peace is of great importance as furnishing the data for the problems he has to study and solve.

J. P. W.

Handbook of Arctic Discoveries, by A. W. Greely, Brigadier-General, United States Army, Chief Signal Offices of the Army, Boston, Roberts Brothers, 1896 Pp. 257, with maps and index.

This work forms the third of the *Columbian Knowledge Series* edited by

Professor D. P. Todd of Amherst College. It represents more than 50,000 pages of original narrative, and although from its very nature 'the story of adventure' and many enlivening incidents have necessarily been omitted, it forms an interesting and valuable summary—a handbook—of what has been done in artic exploration.

Clearness and conciseness of statement, and convenience of reference mark the work throughout. For the student, and reader too, the arrangement of the chapters is of advantage—topical rather than chronological,—"hence such topics as the Northwest Passage, the Northeast Passage, the Franklin Search, International Polar Stations, and Voyages to the North Pole appear under separate and comprehensive chapters."

"This course will tend to dissipate the wide-spread impression that all Arctic voyages have been made for practically the same general purpose, whereas polar research has passed through three distinctive phases: first for strictly commercial purposes in connection with trade to the Indies; second, for advancement of geographic knowledge; and third, for scientific investigations connected with the physical sciences."

In this connection, it is interesting to note that, as the author shows, the Arctic regions, in a little over two centuries, have furnished to the civilized world products aggregating a thousand millions of dollars in value.

Having considered the scope and value of Arctic exploration, the author then gives succinct accounts of the early Northwest voyages, and of those for the Northeast Passage, with interesting descriptions of Nova Zembla and Spitzbergen.

The Northwest Passage by sea and by land, Franklin's voyages and the Franklin search by sea and by land form chapters full of interest and furnish striking examples of man's determination and effort to dominate the most adverse environment.

"Contrary to the general impression, Arctic voyages for reaching the north geographic pole have been the exception rather than the rule;" but under the head of North Polar Voyages accounts are given of the attempts that have been made with this object in view. The discoveries of the islands of the Siberian Ocean, Smith Sound and Robeson Channel, and Franz Joseph Land show the further advancement of geographic knowledge.

The voyages for scientific research recently culminating in the establishment of the circum-polar stations, show the newest phase of polar investigation. "Only since that event has scientific research in Arctic lands been held at anything like its full value; and it is now clear that this imperfectly known northern world is really a most prominent factor in solving useful problems in the physics of the globe."

An attractive feature of the book is the bibliography at the end of each chapter, giving the more important works on the subject considered. In addition thereto, a bibliography of the sources of detailed information forms the last chapter of the work.

Altogether this book seems admirably adapted for the purpose for which it was intended: an excellent handbook of reference "for the busy man who often wishes to know what, when, and where, rather than how."

A. H. Jr.

Military Letters and Essays. Captain F. N. Maude, R. E. International Series, No. 1, edited by Captain A. L. Wagner. Hudson-Kimberly Publishing Co., Kansas City, Mo. Pp. 303.

This series begins very properly with the essays of this representative English officer, whose word has become authority on matters of tactics, who has been constantly alive to all that is going on in the military world, and whose views bear the stamp of originality. These essays are worthy of careful study in connection with the works of Hohenlohe, von der Goltz and Meckel.

The first paper relates to the statistics of the Franco-German war, and we find that although the Germans generally had a great superiority, at Spicheren they *attacked* 23,700 French infantry with 26,000 Germans, at Colombey-Nouilly the decision was given by 30,500 rifles on the German side against 50,700 rifles on the French, at Vionville-Mars-la-Tour the fighting began with 23,700 rifles, against which the French engaged 59,100 rifles; at the close of the day 47,100 infantry on the German side were fighting against 83,600 rifles on the other side. The author remarks that under such circumstances in the War Game the umpire would unhesitatingly say that the attacking force was repulsed with great loss. In the article on smokeless powder we notice a statement very similar to opinions expressed by Grant and Sheridan: "The fact is, every body of troops possesses a certain capacity for resisting loss, and this capacity varies with their discipline and the fighting talent of the race." In this article he shows that the changes in armament favored the prospects of the cavalry being again employed in masses, in the next (The Conditions of Modern Warfare) he sums up with the statement: "I am inclined to believe that the strain of the fighting will again tend to settle on the shoulders of the artillery."

The collection contains dissertations on von der Goltz's pamphlet on *Independent Patrols*, Meckel's *Minor Tactics* and *Midsummer Night's Dream*, Hoenig's *The Two Brigades* and *Twenty-four Hours of Moltke's Strategy* and the new *German Infantry Regulations*, all of which, besides giving us the substance of the several books, instruct us as to their practical value. There are twenty-six essays in all, covering the domain of tactics very fully from all points of view, and furnishing rich mines of food for thought to the military student.

J. P. W.

Water-Supply. (Considered principally from a sanitary standpoint). By William P. Mason, Professor of Chemistry, Rensselaer Polytechnic Institute. New York: John Wiley & Sons. Pp. 504. 8vo. Cloth, $5.00.

The question of water-supply ranks in importance side by side with that of food supply, and in the army both have always received much attention, indeed, our Medical Corps has several members of wide reputation as water analysts. The water supply of a post is often decided by the commanding officer or the quartermaster; moreover, in the field the location of a camp is frequently dependent on the water-supply, and dangers of polution are not always clearly understood. Consequently a knowledge of the subject is essential to every well-informed army officer.

The work of Professor Mason meets the wants of the general reader as well as those of the special student. By his labors during the past few years in perfecting the methods of analysis and in investigating the effect of drinking water on diseases in our eastern cities, he has placed himself in the foremost rank of water analysts.

After a short historical introduction the author discusses the connection between drinking-water and disease, in which some curious and striking facts are brought out.

As regards the relation of drinking water to *malaria* the author quotes, among others, from Dr. Waggener:

"In January, 1886, a company of forty healthy marines were sent to the navy yard at Pensacola, Florida. During their first year frequent attacks of malaria began to show themselves among these men, which increased in number during the second year, and during the third year the disease became so prevalent that, before August, twenty-five of the party were in the hospital at one time. * * * These marines drank the water from a driven well at the yard. The officers and their families drank only from a cistern, and no case of malaria appeared among them."

Again, from Dr. W. H. Daly:

"Observations and studies on the subject, and investigations made in various districts from Manitoba to Louisiana, and all along the southern coast of the Atlantic Ocean, and of Cuba, Yucatan, and certain districts in Mexico, lead the writer to the conclusion that so-called malarial disease is not easily, if at all, contracted by inhaling so-called malaria or bad air of the low, swampy, or new lands, but it is distinctly, if not almost exclusively, due to drinking water that has come into contact with and become infected with the malaria germs that exist in the earth and waters of the swamp and low lands."

Finally, from Dr. Chas. Smart, United States Army:

"The propagation of malarial disease by means of drinking-water has of late years been accepted by those who have made a special study of the subject."

The author's investigations of the *typhoid* epidemic in the valley of the Hudson in 1890-91 are extremely instructive, and the facts he divulges should be well known to every intelligent citizen; the same may be said of the conditions attending the *cholera* epidemic in Hamburg, Germany, in 1892.

The chapter on the artificial purification of water contains descriptions of the filtering methods employed in England, Holland, Germany, Russia and Switzerland. It may be of interest to many to hear what the author has to say of the house filter known as the "Pasteur:"

"Water can be completely sterilized by filtration through porcelain, but the filtration must not be continued for many days at a time. * * * The *candle* and its rubber packing must be removed at least once a week, thoroughly washed, and then boiled for half an hour before being reset in position.".

Under the subject of the natural purificatian of water we find this statement (verified by many citations of facts):

"Aeration of water has always held in the public mind a position of prime importance as a means of purification, and there is unquestioned benefit arising from such source, but the benefit is not to the extent that is popularly believed."

The various sources of natural waters,—rain, ice, snow, rivers and streams, lakes and ponds, ground water and deep-seated waters,—are all discussed from a sanitary point of view, and the points brought out are well worthy of careful study.

The part devoted to the chemical examination of water is excellent;

indeed, it is the best description of the latest and most improved methods in water analysis extant, and the author himself, although he modestly mentions in the preface the fact that the analytical methods "are largely based upon the report of the committee of the American Association for Advancement of Science," has done much to improve and perfect these methods and to bring them to their present state. The bacteriological examination of water goes hand in hand with the chemical and the author gives us a good chapter on that, with some very pertinent remarks on the relative values of the methods and their connection one with the other. The work concludes with an article on the action of water upon metals.

A knowledge of the subject here discussed is of value to every educated man, but particularly to officers of the army, who may at any time be required to decide matters relating to the drinking water ot a post, garrison or camp, and above all to our quartermasters who are constantly coming up against questions relating to water-supply, drainage, sewage contamination and other related matters. A copy of this work at every department and post headquarters, and on every quartermaster's desk would, at the rate at which Farr estimates the average value of a human life ($780), soon pay for itself, and if we take our soldiers as worth what a French soldier is ($1,200), the return will be much more rapid.

The book is well printed on good paper, copiously illustrated, and attractively bound.

J. P. W.

The Pocket Revolver and its Use. United States Cartridge Co., Lowell, Mass. Pp. 32.

This little pamphlet contains some interesting information on the care in handling revolvers, practice in target firing, and the rules for revolver shooting, and will be useful to those who desire to acquire proficiency in this arm.

J. P. W.

The Army and Navy Register, December 5, 1896, Washington, D. C. Price 10 cents..

A special edition containing full *Reports of the Secretaries of War and the Navy.* Other articles ot interest are *English Discourtesy* and *Annual Report of the Fort Riley School.*

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year* £2 6 *d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year* £2 6 *d.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7 *s.*

United Service Gazette. [*U. S. Gazette.*] *Weekly.*
4-6 *Catherine Street, Strand, London, W. C. Per year* £1 10 *s* 6 *d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*
17 *Great George Street, London, S. W. Per year* 2 *s.*

Army and Navy Gazette. [*A. and N. Gazette*] *Weekly.*
3 *York Street, Covent Garden, London. Per year* £1 12 *s* 6 *d.*

Proceedings of the Royal Artillery Institution. [*Proceedings R. A. I.*] *Monthly.*
Woolwich, England.

Journal of the United Service Institution of India. [*Jour. R. U. S. I. India*] *Monthly.*
Simla, India. Per year $2.50.

Canadian Military Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6*d each.*

Electrical Review, [*Elec. Rev.*] *Weekly.*
22 *Paternoster Row, London. Per year* $6.00.

FRANCE.

L'Avenir Militaire. [*Avenir.*] *Semi-weekly.*
13 *Quai Voltaire, Paris. Per year* 18 *Fr.*

Revue du Cercle Militaire. [*Cercle*] *Weekly.*
37 *Rue de Bellechasse, Paris. Per year* 27 *Fr.*

Le Yacht—Journal de la Marine. [*Yacht*] *Weekly.*
55 *Rue de Chateaudun, Paris. Per year* 30 *Fr.*

La Marine Française. [*Marine F.*] *Semi-monthly.*
23 *Rue Madame, Paris. Per year* 30 *Fr.*

Revue Maritime et Coloniale. [*R. Maritime*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 56 *Fr.*

Revue d'Artillerie. [*R. Artillerie*] *Monthly.*
5 *Rue des Beaux-Arts, Paris. Per year* 22 *Fr.*

Revue du Génie Militaire. [*Génie M.*] *Monthly.*
8 *Rue Saint-Dominique, Paris. Per year* 27 *Fr.*

Revue Militaire de l'Etranger. [*Etranger*] *Monthly.*
L. Baudoin, Rue et Passage Dauphine 30, *Paris. Per year* 15 *Fr.*

Le Génie Civil. [*Génie C.*] *Weekly.*
8 *Rue St. Dominique, Paris. Per year* 45 *Fr.*

Journal des Sciences Militaires. [*Sciences Militaires*] *Monthly.*
Rue et Passage Dauphine 30, *Paris. Per year* 40 *Fr.*

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.
[*Ingénieurs Civils*] *Monthly.*
10 *Cité Rougemont, Paris. Per year* 36 *Fr.*

Revue de Cavalerie. [*R. Cav.*] *Monthly.*
Berger Levrault et Cie, Rue des Beaux-Arts 5, *Paris. Per year* 33 *Fr.*

Revue d'Infanterie. [*R. Inf.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Revue Militaire Universelle. [*R. Univ.*] *Monthly.*
11 *Place Saint André-des-Arts, Paris. Per year* 25 *Fr.*

Mémorial des Poudres et Salpêtres. [*M. Poudres et S.*] *Quarterly.*
Quai des Grands-Augustins, 55, *Paris. Per year* 12 *Fr.*

Le Monde Militaire. [*Monde.*] *Fortnightly.*
76 *Rue de Seine, Paris. Per year* 6 *Fr.*

GERMANY.

Militaer-Wochenblatt. [*Wochenblatt.*] *Fortnightly.*
Koch Strasse, 68, *Berlin, S. W.* 12. *Per Year* 20 *M.*

Archiv fuer die Artillerie-und Ingenieur Offiziere. [*Archiv.*] *Monthly.*
Koch Strasse, 68-78, *Berlin, S. W.* 12. *Per year* 12 *M.*

Jahrbuecher fuer die deutsche Armee und Marine. [*Jahrbuecher.*] *Monthly.*
Mohren Strasse, 19, *Berlin, W.* 8. *Per year* 32 *M.*

Marine Rundschau. [*Rundschau.*] *Monthly.*
Koch Strasse, 68-70, *Berlin. Per year* 3 *M.*

Allgemeine Militaer-Zeitung. [*A. M.-Zeitung.*] *Semi-weekly.*
Darmstadt. Per year 24 *M.*

Beiheft zum Militaer-Wochenblatt. [*Beiheft.*]
Koch Strasse, 68, *S. W., Berlin.*

Deutsche Heeres Zeitung. [*Heeres-Zeit.*] *Semi-weekly.*
Wilhelmstrasse 15, *Berlin. Per year* $6.00.

Stahl und Eisen. [*Stahl u. Eisen.*] *Fortnightly.*
Schadenplatz 14, *Düsseldorf. Per year* $5.00.

Kriegswaffen. [*Kriegswaffen.*] *Monthly.*
Rathenow, Germany. Per year $4.50.

Revista Maritima Brazileira. [*R.M. Brazil.*] *Bi-monthly.*
Rue do Conseheiro Saraiva n. 12, *Rio de Janeiro, Brazil. Per year* $10.00.

Revista da Commissao Technica Militar Consultiva. [*R. da Commissao.*] *Bi-monthly. Praça da Republica N.* 32, *Rio de Janeiro, Brazil.*

Circulo Naval,—Revista de Marina. [*R. de Marina.*] *Monthly.*
Casilla num. 852, *Valparaiso, Chili.*

Boletin del Centro Naval. [*Boletin.*] *Monthly.*
438 *Alsina, Buenos Aires, Argentina Republica. Per year* $11.00

El Porvenir Militar. [*Porvenir.*] *Weekly.*
258 *Calle Montevideo, Buenos Aires, Argentina. Per year* 10 $ $\frac{m}{n}$.

HOLLAND AND SCANDINAVIA.

De Militaert Gids. [*M. Gids.*] *Bi-monthly.*
De Erven F. Bohn, Haarlem, Holland. Per year, U. S., $2.00.

Militaert Tidsskrift. [*M. Tids.*] *Bi-monthly.*
Copenhagen, Denmark. Per year, U. S., $2.50.

Norsk Militeert Tidsskrift. [*N. M. Tids.*] *Monthly.*
Christiania, Norway. Per year, U. S., $2.50.

Artillerie-Tidskrift. [*Art. Tids.*] *Bi-monthly.*
Stockholm, Sweden. Per year, U. S., $1.75.

ITALY.

Rivista di Artiglieria é Genio. [*R. Artig.*] *Monthly.*
Tipografia Voghera Enrico, Rome. Per year 30 *L.*

Rivista Marittima. [*R. Maritt.*] *Monthly.*
Rome. Per year 25 *L.*

UNITED STATES.

The Engineering News. [*Eng. News.*] *Weekly.*
Tribune Building, New York City. Per year $5.00.

The Scientific American. [*Scien. Amer.*] *Weekly.*
361 *Broadway, New York City. Per year* $3.00.

The Iron Age. [*Iron Age.*] *Weekly.*
96-102 *Reade Street, New York City. Per year* $4.50.

Journal of the Military Service Institution. *Bi-monthly.*
Governor's Island, New York City. Per year $4.00.

American Engineer and Railroad Journal. [*Eng. and Rail. Jour.*] *Monthly.*
47 *Cedar Street, New York City. Per year* $3.00.

Engineering and Mining Journal. [*Eng. and Min. Jour.*] *Weekly.*
253 *Broadway, New York City. Per year* $5.00.

Electric Power. [*Elec. Power.*] *Monthly.*
27 *Thames Street, New York City. Per year* $2.00.

Digest of Physical Tests. [*Digest.*] *Monthly.*
1424 *N.* 9*th Street, Philadelphia. Per year* $1.00.

The Engineer. [*Eng. N. Y.*] *Fortnightly.*
106-108 *Fulton Street, New York City. Per year* $2.50.

Cassier's Magazine. [*Cas. Mag.*] *Monthly.*
World Building, New York City. Per year $3.00.

Journal of the American Chemical Society. [*J. Chem. S.*] *Monthly.*
Easton, Pa. Per year $5.00.

Journal of the Franklin Institute. [*Frank. Inst.*]
Per year $5.00.

Journal of the Western Society of Engineers. [*W. Soc. Eng.*] *Bi-monthly.*
1737 *Monadnock Block, Chicago, Illinois. Per year* $2.00.

Marine Review. [*Mar. Rev.*] *Weekly.*
Cleveland, Ohio. Per year $2.00.

Pennsylvania Magazine of History and Biography. [*P. Mag. of Hist.*]
Quarterly.
13 *Locust Street, Philadelphia. Per year* $3.00.

Physical Review. [*Phys. Rev.*] *Bi-monthly.*
Cornell University, Ithaca, New York. Per year $3.00.

Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
72 *Fifth Avenue, New York City. Per year* $5.00.

Proceedings of the U. S. Naval Institute. *Quarterly.*
Annapolis, Md. Per year $3.50.

Public Opinion. [*Pub. Opin.*] *Weekly.*
New York City. Per year $2.50.

Army and Navy Journal. [*A. and N. J.*] *Weekly.*
New York City. Per year $6.00.

Army and Navy Register. [*A. and N. R.*] *Weekly.*
Washington, D. C. Per year $3.00.

American Machinist. [*Amer. Mach.*] *Weekly.*
256 *Broadway, New York City. Per year* $3.00.

Review of Reviews. *Monthly.*
13 *Astor Place, New York City. Per year* $2.50.

The United Service. [*U. Serv.*] *Monthly.*
1510 *Chestnut Street, Philadelphia. Per year* $2.00.

Journal American Society of Naval Engineers. [*A.S.N. Egrs.*] *Quarterly.*
Navy Department, Washington, D. C.

Military Information Division. [*Mil. Inf. Div.*]
War Department, Washington, D. C.

The Photographic Times. [*Phot. Times.*] *Weekly.*
60 *and* 62 *E.* 11*th Street, New York City.*

ORGANIZATION AND ADMINISTRATION.

Condition of the army, U. S.—**A. and N. Jour.**, November 14.

TACTICS, STRATEGY AND MILITARY HISTORY.

The rôle of the brigade of an army corps and its composition.—**R. Cavalerie**, August.

The second line.—**A. and N. Gazette**, October 10.

The 2nd Brigade in the Chitral relief expedition, 1895.—**Jour. R.U.S.I.**, October.

Critical study on the operations of the XIV. German corps in the Vosges.—**Sciences Militaires**, October.

The putting in motion of several armies.—**Heeres-Zeit.**, September 23.

Impedimenta in war.—**Int. Rev. A. and F.**, May.

Studies on applied tactics; the battle of le Bourget, October 3, 1870.—**Heeres-Zeit.**, September 26.

The Soudan expedition.—**A. and N. Gazette**, September 12, 19.

The Anglo-Egyptian expedition.—**A. and N. Gazette**, September 12.

The Egyptian troops in the Soudan.—**U. S. Gazette**, September 12.

Campaigns of the English in Egypt and the Soudan.—**R. Infanterie**, September, October.

The campaign on the Nile.—**Pub. Opin.**, October 8.

The Matabele insurrection (with map).—**Cercle**, September 19, 26.

Expedition of the English against the Ashantis.—**Etranger**, September.

The battle of Ferkeh of the English-Egyptian expeditionary corps.—**Monatsch.**, September.

Train service in the campaign of the English in Abyssinia (detail of some colonial expeditions).—**Sciences Militaires**, October.

The battle of Hafir (Soudan).—**A. and N. Jour.**, November 14.

The Zanzibar bombardment.—**A. and N. Gazette**, October 3.

The bombardment of Zanzibar.—**U.S. Gazette**, October 10.

The Madagascar expedition.—**Avenir**, September 15, 18, 29. October 2, 6, 9.

Affairs in Madagascar.—**Avenir**, September 25.

Letters from Madagascar.—**Cercle**, September 26.

The conquest of Madagascar.—**Pub. Opin.**, October 15.

The destruction of the French troops in the campaign of the French in Madagascar.—**A.M. Zeitung**, September 21, 24, 28.

Expedition to India, 1895–96.—**Exercito**, September.

French aggrandizement in farther India.—**Jahrbucher**, October.

The Franco-Brazilian dispute.—**Marine F.**, September 10.

The insurrection in the Philippines (note).—**Cercle**, September 12.

The political and military situation in Cuba.—**Cientifico**, August 15.

Spanish politics.—**Pub. Opin.**, October 15.

The revolt in Cuba, General Ochano.—**A.M. Zeitung**, September 14.

The war in Cuba.—**A.S.M. Zeitung**, June 20.

Military considerations on the campaign in Cuba.—**M. de Art.**, September.

Official report on the battle of Adowa.—**R. Infanterie**, September, October.

The war between Japan and China.—**M. Tids.**, Part 6, 1896.

The Chino-Japanese war.—**Cientifico**, September 15.

The Chino-Japanese war.—**Proc. R.A.I.**, August.

On the memoir: "The battle of the Yalu."—**Yacht**, September 15, 19.

History of the French infantry.—**R. Infanterie**, September, October.

Present tendencies of the German infantry.—**Cientifico**, August 15.

Artillery from an infantry officer's point of view.—**Proc. R.A.I.**, June.

The Yorktown campaign of September and October, 1781.—**United Service**, October.

Turenne's campaign, 1654.—**Sciences Militaires**, October.

The French generals of 1870.—**S. Zeitschrift**, September.

The Franco-German war, 1870-71.—**Vereine**, liii. 2.

The Bourbaki army in the Franco-Prussian war.—**Monatschr.**, September.

French opinions on the troop-leading of the Germans in 1870-71.—**A.M. Zeitung**, August 10.

Events on the sea during the Franco-German war.—**Seewesens**, No. 10.

Metz in 1870.—**Avenir**, September 18, October 2.

The German siege operations at Malmédy.—**A.S.M. Zeitung**, September 19.

Could Marshal Bazaine have saved France in 1870.—**R. Univ.**, October.

The causes of the defeat of the French army in 1870.—**A. M. Zeitung**, September 3, 8.

Southern Normandy in the defense of France.—**R. Univ.**, October.

The defense in the north (France).—**Marine F.**, September 10.

Napoleon III.—**A.M. Zeitung**, August 7, 10, 13, 17, 20.

Napoleon and St. Martin.—**Boletin**, June-July.

Campaign of Soult in Portugal.—**Exercito**, August.

Our first riflemen, Portugal.—**R. Mil.**, Portugal, August 31.

From Lützen to Bautzen, May 1813.—**R. Cavalerie**, August.

The Prussian war-plan of 1756 and the cause of the seven years' war.—**Jahrbucher**, October.

The battle of Striegau, June 4, 1745, in the light of recent investigation.—**A. M. Zeitung**, September 21, 24, 28.

Field Marshal Derfflinger.—**Beiheft**, No. 7 and 8.

Derfflinger.—**Heeres-Zeit.**, October 17.

Field Marshal Count Moltke and the young strategical school.—**Heeres-Zeit.**, October 7.

Lieutenant General von Gossler, the new Prussian War Minister.—**A. M. Zeitung**, August 17.

Peter the Great.—**Cercle**, September 26.

The Czar at Paris and the review at Chalons.—**Cercle**, October 3.

The Russian occupation of Bulgaria.—**Jahrbucher**, October.

The revival of Montenegro.—**Pub. Opin.**, October 8.

The eastern question, Gladstone's speech.—**Pub. Opin.**, October 1.

England and Russia; why Russia distrusts England.—**Pub. Opin.**, Oct. 29.

The Anglo-Belgian alliance.—**Avenir**, September 16.

The Italo-Tunisian treaty.—**Pub. Opin.**, October 29.

Arbitration, national arbitration.—**Pub. Opin.**, October 8.

Australian federation.—**Pub. Opin.**, October 8.

Spain and the United States.—**A. and N. Jour.**, November 14.

International maritime law in time of war.—**Rundschau**, October.

Studies on war.—**Wochenblatt**, September 9.

What war means.—**U.S. Gazette**, October 10, 17.

Railways in war.—**Cientifico**, August 15.

Railroad for the seat of war on the upper Nile.—**Wochenblatt**, Sept. 26.

The fog of war ("the state of ignorance in which commanders frequently find themselves as regards the real strength and position, not only of their foes, but also of their friends"), Colonel Lonsdale Hale, Royal Engineers.—**Aldershot Military Soctety**, March 24.

The nation in arms.—**Belgique M.**, August 2.

The chimera of disarmament.—**Sciences Militaires**, October.

DRILL REGULATIONS AND MANEUVERS.

Field service regulation of May 28, 1895.—**Cercle**, September 12, 19.

The practical instruction of artillery in France and Germany.—**Heeres-Zeit.**, September 5, 9.

Utility of the uniformity of regulations for the service of our position and field artillery.—**M. de Art.**, August.

Service of the 28 cm. Krupp gun.—**R. da Commissao**, June, July.

Artillery exercises, Portugal.—**R. Mil.**, Portugal, August 31.

The French artillery's firing rules of March 14, 1894.—**Art. Tids.**, 1 and 2, 1896.

An account of the different schools of instruction, drills, etc., of the field artillery of Sweden during the practice year, 1894-95.—**Art. Tids.**, 1 and 2, 1896.

Practice firing of field artillery during the winter season and against balloons.—**Art. Tids.**, 1 and 2, 1896

Russian field firing practice.—**S. Zeitschrift**, September.

A new method of inspection for the Russian artillery (drill and firing practice).—**Wochenblatt**, October 3.

Modifications of the Russian firing regulations 1893.—**Wochenblatt**, September 15.

On the question of new requirements for practice firing.—**Wochenblatt**, September 9.

New target practice.—**Wochenblatt**, September 30.

The training of infantry in outpost and patrol duty.—**N. M. Tids.**, part 2, 1896.

Instruction in field fortification.—**Prof. papers, Corps Royal Eng'rs.**, Vol. I.

The training of our army, England.—**U. S. Gazette**, September 26.

Athletic training for soldiers.—**A. and N. Jour.**, October 17.

Essay on the practical instruction of our cavalry.—**R. Cavalerie**, August.

Instruction of n. c. o. pupils.—**Monde**, October 1.

Initiative and discipline.—**Avenir**, October 2.

The infantry sword exercise of 1895.—**U. S. Gazette**, September 12.

New paces of the troops, Argentine Republic.—**Porvenir**, July 8.

The military training of dogs.—**U. S. Gazette**, September 26.

The grand maneuvers, France.—**Avenir**, September 15.

French grand maneuvers.—**R. Cavalerie**, August.

French army maneuvers.—**A. and N. Jour.**, October 17.

Our grand maneuvers, France (*fin de siècle* strategy).—**R. Cavalerie**, September.

French maneuvers, 1896.—**Heeres-Zeit.**, September 26.

The French naval maneuvers.—**Eng'ing.**, September 11, 25; **U. S. Gazette**, September 2 , October 3,

Two reconnaissances by officers in the maneuvers of 1895, France.—**R. Cavalerie**, September.

Maneuvers of the 2nd cavalry division at Camp Beverloo.—**Belgique M.**, October 2.

The Aldershot maneuvers.—**A. and N. Gazette**, September 12.

The recent Aldershot maneuvers and their lessons.—**U. S. Gazette**, September 19.

ARTILLERY MATERIAL.

The Johnson capped projectile.—**A. and N. Jour.**, September 26.

Modern projectiles, influence of their improvement on the construction of war ships.—**R. de Marina**, August.

A new high explosive projectile.—**Kriegswaffen**, VII, No. 1.

Report of the commission on explosive substances, 1894-95.—**M. des Poudres et S.**, 1895-96, II.

Dupont smokeless rifle powder.—**Shooting and Fishing**, September 24.

Nitro powders in rifles.—**Shooting and Fishing**, October 8.

Indurite or naval smokeless powder.—**Eng. News and R. R. Jour.**, October 29.

Smokeless powder and its application to artillery service.—**M. de Art.**, September.

Military and sporting smokeless powder.—**Mitth. Art. und G.**, Nos. 8 and 9.

Modern powders.—**A. and N. Jour.**, November 14.

Bag cartridge with metal case and priming cap.—**Kriegswaffen**, VII, No. 1.

The Nobel factory.—**Arms and Expl.**, October.

Chilian nitrate of soda deposits.—**Eng'ing.**, October 30.

Large explosions and their radii of danger.—**Engineering**, October 9, 23.

The Howell torpedo.—**A. and N. Jour.**, November 7.

Detailed account of improvements and modifications, latest constructions in cannon and small-arms.—**Kriegswaffen**, VI. No. 12.

Notes on latest inventions and discoveries in the chemical and technical military line.—**Wochenblatt**, October 7, 10.

BALLISTICS, RANGE FINDING AND POINTING.

A study on the ballistics of modern powders.—**R. M. Brazil**, September.

Study on the maximum pressures in sporting rifles, gun cotton powders used.—**M. des Poudres et S.**, 1895-96, II.

Report on the development of a photo-retardograph and its application to the dynamic measurement of resistance to compression offered by the copper cylinders used in crusher gauges (B. W. Dunn).—**Ordnance Note, No. 71.**

Polarizing chronograph (Squier and Crehore).—**Génie C.**, August 15.

Experiments with polarizing chronograph for determining the velocity of a projectile in the bore of a gun.—**Génie C.**, August 22.

Experimental determination ot the motion of a projectile in the bore of a gun.—**Scien. Amer.**, October 24.

Telemeters.—**R. M. Suisse**, October 15.

Grant's automatic sight for coast guns.—**Eng.**, October 23.

Description of an aiming apparatus for heavy guns for use at night.—**Art. Tids.**, 1 and 2, 1896.

Indirect fire, apparatus for "elliptic pointing."—**R. Artillerie**, September.

Method of bringing into parallelism the lines of sight of several guns in a given direction for the purpose of firing from covered emplacements.—**Kriegswaffen**, VII, No. 1.

The test of the long range.—**Scien. Amer.**, October 31.

METALLURGY.

Sir Henry Bessemer.—**Cas. Mag.**, September, October.

American blast furnace practice.—**Amer. M. and Iron World**, October 23.

The presence of fixed nitrogen in steel.—**Amer. M. and Iron World**, October 23.

Fixed nitrogen in steel.—**Iron Age**, Octaber 8.

Formulae for determining the values of iron ores.—**Eng. and Min. Jour.**, October 10.

The estimation of sulphur in iron ores.—**Amer. M. and Iron World**, October 30.

Some physical properties of malleable cast-iron.—**Digest**, October.

The effect of cold on iron.—**Iron Age**, October 8.

Behavior of iron at an abnormally low temperature.—**Digest**, October.

ELECTRICITY AND HYDRAULICS.

Electric turret-gear for French war ships.—**Elec. Eng.**, September 16.

Electric motors in the navy.—**Yacht**, October 17.

Applications of electricity in the navy (rapid fire guns, etc.).—**Boletin**, June-July.

Electricity on board ships.—**Mar. Rev.**, September 17.

Naval uses of electricity.—**U.S. Gazette**, September 12.

Electricity in naval life (Fiske).—**Elec. Eng.**, September 23, 30; October 7, 14, 21.

Electricity in naval warfare.—**A and N. Gazette**, September 19.

Bullets swerved by electricity.—**Scien. Amer.**, September 26.

Projectiles and electric telegraph lines.—**R. M. Suisse**, September 15.

Electrical material.—**Boletin**, June-July.

Tesla's electrical condensers.—**Elec. Rev.**, September 23.

Tesla's electrical oscillators.—**Elec. Rev.**, September 30.

An electric motor for a submarine torpedo-boat.—**Seewesens**, No. 10.

An electric telegraph without any line, Danish.—**Elec. Rev.**, October 7.

Development of the electric search light.—**Mar. Rev.**, October 29.

The phonograph.—**Eng'ing**, October 9.

Electricity direct from carbon.—**Jour. Frank. Inst.**, November.

Niagara on tap.—**Jour. Frank. Inst.**, October, November.

Electrical tests of power required by metal working machinery at the U. S. Navy Yard, Washington, D.C.—**Amer. Mach.**, October.

Electric smelting furnace.—**Iron Age.**, October 8.

FORTIFICATIONS.

Fortifications of the city and port of Rio Janeiro.—**R. da Commissao**, June, July, August.

The new defenses of Copenhagen.—**Prof. papers Corps Royal Eng'rs**, Vol. I.

Land defense and the art of fortification (Brialmont).—**A. S. M. Zeitung**, October 3.

The defense of Metz by armored fronts.—**Prof. papers Corps Royal Eng'rs**, Volume I.

BICYCLES, ÆROSTATION, PHOTOGRAPHY.

Bicycle tools.—**Amer. Mach.**, September 17.

Bicycle repairing.—**Iron Age**, September 17, 24; October 15, 22.

Chain making and cycle tools.—**Amer. Mach.**, September 24.

Making balls for bearings —**Amer. Mach.**, October 1.

Bicycle frame tests.—**Iron Age**, September 17.

The bicycle wheel.—**Scien. Amer.**, October 17.

Fabric for bicycle tires; testing tubes.—**Amer. Mach.**, October 29.

Interesting facts about bicycles.—**Eng. N. Y.**, September 26.

The bicycle relay race across the continent.—**Scien. Amer.**, September 19.

Wheeling across the continent.—**A. and N. Jour.**, September 26.

Motor cycle trials in France.—**Eng.**, September 25.

The Dion, Bouton and Co., tricycle and the Bollee carriage.—**Scien. Amer.**, October 17.

The horseless carriage of the future.—**Eng.**, September 18.

The military bicycle in Portugal.—**R. Mil. Portugal**, September 15, October 15.

The military bicycle in Germany.—**R. da Commissao**, August.

Notes on the employment of cyclists in the army, Norway.—**N. M. Tids.**, Part 2, 1896.

A detachment of bicycle cavalry sappers, pioneers (note).—**Cercle**, October 3.

The bicycle for military purposes.—**A. and N. Reg.**, November 14.

A velocipede ambulance.—**Scien. Amer.**, October 10.

Cam gear cycle.—**Eng.**, October 9.

Military ballooning, Aldershot school.—**A. and N. Jour.**, September 19.

A new dirigible balloon.—**Scien. Amer.**, October 3.

D. Schwarz's new air-ship.—**A. M. Zeitung**, September 14.

Balloon experiences in war time.—**Scien. Amer.**, September 19.

Artificial flight.—**Eng.**, September 11.

Experiments with large wind propellors.—**Z. Architekten Vereines**, September 4.

The Joly process of color photography.—**Amer. Phil. Soc.**, August.

Photography in colors.—**Cosmopolitan**, October.

Photography in colors.—**Pub. Opin.**, October 15.

The application of photography to surveying.—**Eng. News and R.R. Jour.**, November 19.

SMALL ARMS AND EQUIPMENTS.

The British service rifle.—**A. and N. Jour.**, September 19.

Modern magazine guns.—**Wochenblatt**, September 19, 23.

Experiments with Mauser rifles of Oviedo.—**M. de Art.**, August.

The Mauser rifle and its evolution.—**R. da Commissao**, June, July, August.

The Oviedo factory and the first Spanish Mausers.—**Cercle**, October 10.

Small arms of the Portuguese army.—**R. Mil. Portugal**, August 31, September 15.

Study on the rifle, m. 1886, and its qualities both for collective and individual fire.—**R. Infanterie**, September, October.

The proper rifle for war.—**Cercle**, October 17, 24, 31.

The rise and development of the American rifle.—**Shooting and Fishing**, November 26.

The Savage gun.—**A. and N. Jour.**, October 3.

The New York state gun contest.—**Amer. Mach.**, October 29.

The new infantry rifle.—**Jour. M.S.I.**, November.

Comparative merit of the .30 and .45 caliber U. S. rifles.—**Shooting and Fishing**, November 26.

Damascus gun-barrels.—**Iron Age**, October 8: **Jour. Frank. Inst.**, November.

The Rabbeth sub-caliber projectile.—**Shooting and Fishing**, October 29.

Lubricating modern bullets.—**Shooting and Fishing**, October 22.

A new blank cartridge.—**A. and N. Jour.**, October 3.

Sporting arms.—**R. Artillerie**, September, October.

The hunting knife and rifle pit.—**Jour. M.S.I.**, November.

Spring lever lock for hand fire-arms.—**Kriegswaffen**, VII, No. 1.
Revolver, Grinnell's.—**Kriegswaffen**, VII, No. 1.
The new sabre (note).—**R.M. Suisse**, September 15.
Skobeleff's opinion on the lance.—**Cercle**, September 12; **A. M. Zeitung**, September 17.
Lightening the infantry pack.—**A.M. Zeitung**, August 20.
The Lewis equipment.—**Can. Mil. Gazette**, October 1.
Sac-tender for officers.—**Avenir**, October 2.
A field glass for the field artillery.—**N.M. Tids**, 1 and 2, 1896.
Military hospital equipment, England.—**U.S. Gazette**, October 24.
Marching shoes for troops.—**Jour. M.S.I.**, November.
The soldier's foot covering.—**U.S. Gazette**, November 14.

MILITARY GEOGRAPHY.

Zanzibar.—**Avenir**, September 8.
Letters from Madagascar.—**Cercle**, September 12; October 3, 10, 24.
Madagascar.—**R. Maritime**, September.
District of Timor, East Indies.—**Exercito**, August.
Activity in railroad building in Central America.—**Iron Age**, October 1.
New steamship and railroad lines for Venezuela.—**Engineer**, October 9.
The Tampico harbor works, Mexico.—**Inst. Civil Eng'rs., London**, Vol. CXXV.
Harbor improvements in Western Australia.—**Eng'ing.**, October 2.
The new Soo lock.—**Scien. Amer.**, October 10.
The canal lock at Bremerhaven.—**Scien. Amer.**, October 10.
The Baltic and North Sea canal (note).—**Marine F.**, October 10.
The Danube ship canal.—**Scien. Amer.**, October 31.
The Iron Gates of the Danube.—**Eng.**, October 2.
The opening of the Iron Gates.—**Z. Architekten Vereines**, October 2; **Cercle**, October 3.
The Iron Gates canal.—**Avenir**, September 29.
The Russian canals.—**Marine F.**, October 10.
A new port for Russia.—**Scien. Amer.**, November 7.
The trans-Siberian railroad.—**Génie C.**, October 3; **Cercle**, October 10.
The Lake Biwa- Kioto canal, Japan.—**Scien. Amer.**, November 7.
About the Marmora.—**A. and N. Jour.**, October 31.
The Dardanelles.—**A. and N. Gazette**, October 24.
Siam's new railway.—**Scien. Amer.**, November 21.
A harbor of refuge, U. S. (mouth of Delaware Bay).—**Eng. News and R.R. Jour.**, October 29.

MILITARY SCHOOLS.

Dissolution of the war and naval College, France.—**Avenir**, October 20.
The school of high maritime studies, France.—**Avenir**, October 16.
The school of high maritime studies, France.—**Cercle**, October 24.
The new French naval college.—**Eng'ing.**, November 20.
A high war college, Argentine Republic.—**Porvenir**, September 8.
Military instruction at the Polytechnicum, Switzerland.—**A. S. M. Zeitung**, October 10.
Army schools.—**A. and N. Gazette**, October 24.
Military instruction in schools.—**Cientifico**, September 1.

WARSHIPS AND TORPEDO BOATS.

Engines of the torpedo boat destroyers, *Salmon* and *Snapper*.—**Eng'ing.**, October 23.

French and English warships.—**A. and N. Gazette**, October 3.

French and English armored cruisers.—**Marine F.**, October 10.

The launching of the *St. Louis*, first-class battleship.—**Yacht**, September 12.

Construction of the battleship, *Gaulois*.—**Génie C.**, October 3.

Building of ships of the German navy.—**A. M. Zeitung**, August 3.

Naval constructions in Germany.—**Yacht**, September 5, October 17.

S.M. torpedo boat *Viper*.—**Seewesens**, No. 10.

The Austrian torpedo boat, *Viper*.—**R. Maritime**, September.

The Argentine cruiser *Garibaldi*.—**R. Maritt.**, October.

The cruiser *Cristobal Colon*.—**R. G. de Marina**, October.

The new torpedo boats for Chili and Turkey, *Amiral Simpson* and the *Seetinger*.—**Yacht**, September 15.

The torpedo boat *Entre Rios*.—**Yacht**, October 10.

Torpedo boat destroyer *Entre Rios*.—**Eng'ing.**, October 2.

Torpedo gun boat for the Chilian navy.—**Eng.**, September 18.

Automobile torpedoes.—**R. G. de Marina**, October.

The perfect battleship.—**A. and N. Jour.**, November 7.

Classification of war ships.—**U. S. Gazette**, September 12, **R. G. de Marina**, October.

Safety in ships.—**Eng.**, September 25; **Eng. N.Y.**, October 24.

On the stability of warships.—**R. Maritt.**, October.

Marine engine design of to-day.—**Eng. N.Y.**, September 26.

The engines of English warships.—**Seewesens**, No. 11.

Management of marine engines.—**Eng. N.Y.**, October 10.

Marine evaporators.—**Cas. Mag.**, November

The problem of speed.—**R. M. Brazil**, August.

Use of pulverized oil as fuel.—**Genie C.**, September 26.

The use of patroleum (fuel).—**R. G. de Marina**, September.

Petroleum as a liquid fuel.—**R. M. Brazil**, August.

The naval construction company's works at Yarrow.—**Eng'ing**, Sept. 18.

Government dry-dock at Port Orchard, Puget Sound, Washington.—**Scien. Amer.**, October 3.

The maritime arsenals of Italy.—**M. de Art.**, August.

Considerations on the number and caliber of guns necessary for the armament of a large ship.—**R. Maritime**.

Protection of artillery on ships and the new shields.—**Yacht**, October 3.

The invisibility of torpedo-boots and electric search lights.—**Yacht**, October 3.

MISCELLANEOUS.

Experiments on the protection of steel and aluminum exposed to sea-water. —**Amer. Soc. Civil Eng'rs.**, September.

Aluminum vessels (utensils).—**Exercito**, August.

The shelter tent for cavalry.—**Jour. Cav. Assoc.**, September.

Open air stabling for cavalry horses.—**U.S. Gazette**, October 3.

Casualties in modern battles.—**A. and N. Jour.**, September 19.

Remarkable battle casualties.—**U.S. Gazette**, October 3.

Effect of the small bore rifle on surgery.—**U.S. Gazette**, October 10.

The convention of Geneva and the care of the sick and wounded in war.—Jour. R.U.S.I., October.

Method of instruction in first aid.—Jour. M.S.I., November.

The new St. Lawrence bridge at Montreal.—Eng. News and R.R. Jour., September 24.

The new East River bridge.—Iron Age, September 24.

The metric system (Mendenhall).—Pop. Science, October.

Water supply and sewerage as affected by the lower vegetable organisms.—Jour. Assoc. Eng. Soc., September.

Methods and results of stadia surveying.—Jour. Assoc. Eng. Soc., September.

On war maps.—Jahrbucher, October.

A classification list of books and publications on military professional subjects.—Mil. Information Div., No. 10.

CONTENTS BY NUMBERS.

NO. 1.

NO. 2.

NO. 3.

INDEX TO VOLUME VI.

JULY—DECEMBER, 1896.

* Denotes an original article. Italics denote *Book Notices*.

CORRIGENDA.

Page 160, line 6, for diameter read thickness.

Page 339, foot note, for 44.11 read 4411.

Page 340, line 14, for 104 read 0.04.

Page 342, line 11, for *the* 280 read *to* 280.

Page 344, line 8, Lieutenant S. D. Sturgis, 4th Artillery, suggests that, since the number of balls (for equal densities) is proportional to the *squares of the tangents* of half the angles of opening of the cone, and not to the *tangents*, this line should read

$$300 \frac{\tan^2 9^\circ}{\tan^2 11^\circ 2' 30''} = 205.$$

This would give a minimum weight of projectile of 5.5 kg. The proper weight would then be between 5.5 and 7.5 kg., and the subsequent reasoning in the text would remain the same, except that the minimum limit is thus reduced.